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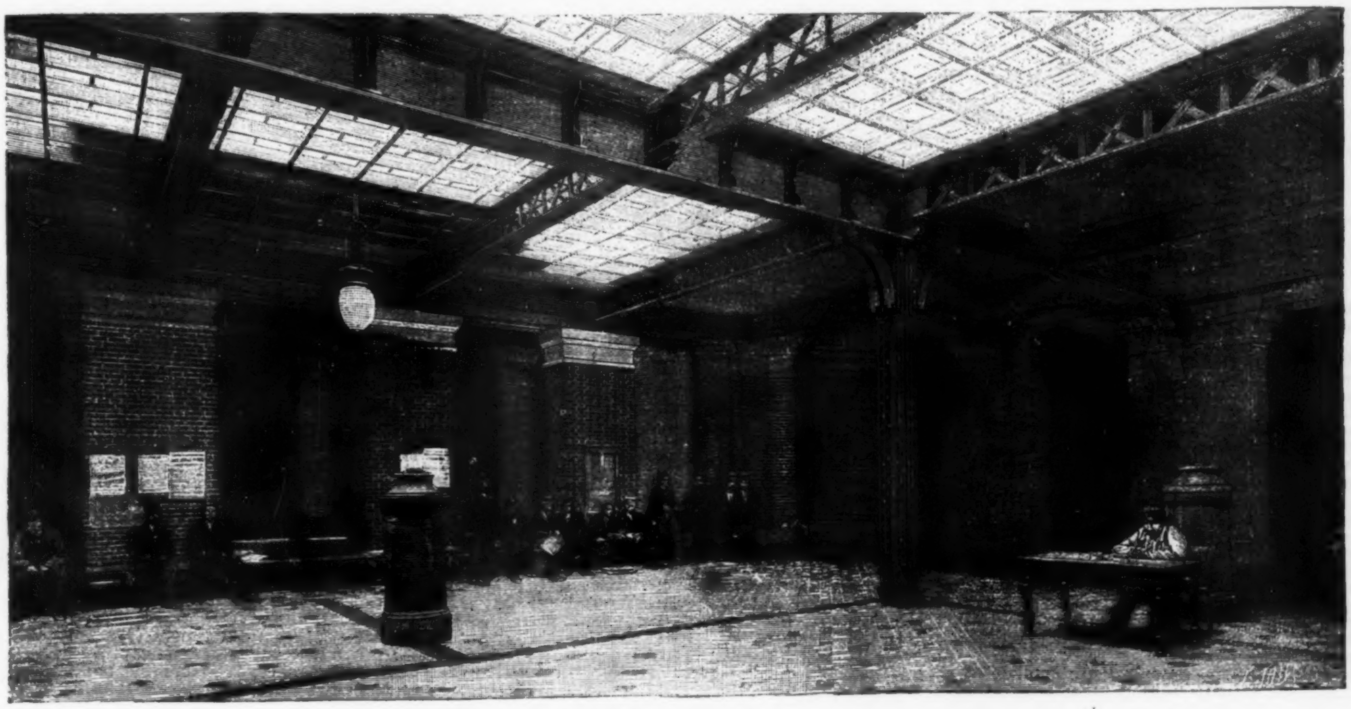


THE LABOR EXCHANGE—HALL OF STRIKES.

ENTRANCE TO THE LABOR EXCHANGE ON CHATEAU D'EAU STREET.

THE LABOR SYNDICATES AND THE LABOR EXCHANGE.

THE labor question, which, as every one is aware, is the great problem of the day, seems this time to have entered a bitter phase. The strike of the coachmen, not yet finished, a resounding conflict, the result of the contest that has long been going on between the government and the professional syndicates—such are the incidents that have just put the world of labor (the Fourth State as it calls itself) once more abruptly in relief, as well as the institution in which it holds its sessions, the Labor Exchange.

Syndical organization, Labor Exchange and strikes are three things that are closely connected and are the three means that the laborers of to-day employ for marching to the conquest of what they call their economical and social emancipation. Through the professional syndicates they organize themselves, through the Labor Exchange they extend themselves from group to group, and through strikes they defend themselves, or claim to do so.

We have not got to go to the very bottom of the debate, but, being given the present phase of the evolution of the relations of work with capital, we shall be content to explain motives and especially to show men and things by taking the reader into this Labor Exchange in the very midst of the syndicates.

Lauded out of measure by those who consider it as the universal panacea for the maladies of labor, and as the criterion of an economical march to the front, the syndicate is also criticised without restriction by those for whom it is only an empirical remedy, a vulgar charlatanism, a retreat, a pure and simple return to the corporation of old, with its exclusiveness and its tyranny. In any event, the only fact that is discussed with passion attests its importance and its vitality, and it has, it is certain, taken on, in recent years especially, a development that must cause us to reflect, without wishing to give it, however, any more power than it really has.

The object of the labor syndicate is easy to understand and explain. It is as follows: To unite in one and the same association, from which every employer is excluded, persons under salary practicing the same profession or trade; to discuss and cause a settlement of the common claims; to create, by means of obligatory contributions, a fund for immediate relief in case of sickness, individual accident or strike of the entire corporation; and, finally, to put aside the common money, which, put at interest, will assure a pension to the members.

All this is evidently strictly legitimate. It will be easily understood, too, that institutions of this kind, recognized by the legislature in 1884, have rapidly prospered, and that the syndicates have immediately endeavored to unite into groups, groups into unions and unions into federations, local at first and then general, national and international, thus founding, through the agreement become common, the common action also, the extent and efficiency of which ought to benefit by such organization.

The laborers of the first category are syndicated as follows: Transportation, building, metallurgy, fabrics, chemical products, food supplies, the book industry and sundries. At the head of these organizations are the railways with 100 groups, the metallurgists with 67, the tobacconists with 18, navigators and sailors with 60, etc. The whole comprises 1,250 labor syndicates, which form a total of 1,300,000 persons.

Now the national labor is divided thus: Agriculture, 17,698,402 laborers; the industries, 9,289,207; transportation, 1,020,721; say 28,000,000 laborers.

Here is material to reassure adversaries and also to astonish exalted partisans.

Only 1,300,000 syndicated out of 28,000,000 are few in reality; and the contrast will appear more formidable still, when we reflect that half of these, that is to say, the 17,098,402 agricultural laborers, half the totality of French labor, is still, up to this day, completely refractory to the idea of the syndicate.

The idea is progressing, however, that is indisputable. This syndical organization just spoken of needed up to recent times a center and rallying point. The institution of labor exchanges and their creation has definitely completed it by furnishing the proletariat a place for its discussions, meetings, etc.

Let us first, very rapidly and very succinctly, present the history of syndical legislation. This will lead directly to an explanation of the present conflict.

In 1776 Turgot obtained an edict from the king abolishing corporations. The first article said: It will be permissible to all persons, of whatever quality and condition they be, and even to all foreigners, to engage in whatever kind of trade and practice whatever profession as seems proper to them, and even to unite several of them.

On the 17th of March the National Assembly confirmed this edict, and on the 17th of June following aggravated it further through the passage of what is known as the Chapelier law. Not only did the legislator abolish corporations at this epoch, but he aimed directly at the combination of laborers and strikes.

This law is important, since, so to speak, it has served as a basis for all the regulations that have followed it. The following is a *resume* of it:

Article I. abolishes corporations; Article II. forbids citizens even to unite in order to discuss what they claim to be their common interests; Article III. is to be cited in its entirety: "If, against the principles of liberty and the constitution, citizens attached to the same professions, arts and trades enter into deliberations or make compacts with each other tending to refuse concert or to accord only at a determinate price the co-operation of their industry or of their work, the said deliberations shall be declared unconstitutional, inimical to liberty and the declaration of the rights of men and of no effect. The administrative or municipal bodies are bound to declare them such. The authors, chiefs and instigators who will have provoked them, written the proceedings or presided, will be cited before the tribunal of police at the request of the procurator of the commune, be each of them condemned to pay a fine of £500 and be suspended for one year from the exercise of their rights as citizens."

Articles VI., VII., and VIII. of the Chapelier law provide against the clandestine posting of such deliberations, and the penalty for which they make £1,000; violence against laborers refusing to go on a strike; and, finally, the assembling of laborers, which they consider as seditious, and which are to be suppressed with the utmost rigor, that is to say, with fire arms.

As may be seen, the republic, one and indivisible, was the resolute adversary of the labor agreement and of the syndicate.

The law of the 22d Germinal, year XII., confirms the penal code of 1810, and adds still further severity to the ancient edicts. All reunions of laborers are absolutely forbidden. Article 415 of the penal code expressly says:

"Any combination on the part of laborers for causing a cessation of work, for preventing work in a shop, for preventing a person from going thereinto or staying therein before or after certain hours, and, in general, for suspending and preventing work or raising the price thereof, will be punished with an imprisonment of from one to three months; foremen and inciters, from two to five years."

Things remained thus under the Restoration, the government of July, and the revolution of 1848.

In the first years of the second empire, the tentatives of the syndicates were proceeded against with the utmost severity. Three thousand pounds fine, imprisonment, loss of civil rights and surveillance by the police for five years were the honors paid to the member of a syndicate, who, as may be seen, was considered as a state criminal.

Then, all at once, there was a change. The empire, in the presence of the more and more fault-finding bourgeoisie, thought it ought to seek an aid in the laborer.

Mr. Emile Ollivier, converted to the liberal empire, wrote in a report:

"It has not seemed well to us to inflict a particular aggravation upon ringleaders. If there are ringleaders who excite, there are also those who restrain. In trying to reach the first, we run the risk of discouraging the second.

"We have not wished, when laborers full of good will have been selected by their comrades as being more capable than others of debating questions of salary with employers, that they should necessarily be punished with particular severity, if, later on, the contest having impelled them, they committed some act of violence or fraud."

Here, then, is the labor coalition officially justified and authorized.

But it was to belong to the republic, in the name of liberty, to completely rehabilitate the co-operative work that the republic had utterly destroyed in the name of this same liberty. The law of 1884 largely contributed to it. In fact, it is restrictive only in two points, which cause it to be qualified as *reactionary* and *policial* by the very ones who benefit by it. Reactionary because one of its articles forbids syndicates to own anything; and policial because another of its articles obliges these syndical organizations to deposit at the prefecture and the *parquet* the statutes that govern them and the names of their members.

In order to fight the first of these articles, the syndicates are as yet keeping themselves within the domain of discussion, but as regards the second, we are at this very moment upon the ground of the action begun.

To the government that enjoins the syndicates to conform to the policial article they respond by a plea in bar, a categorical refusal; they get up an agitation and involve in their rebellion against the law the municipal power, which has constituted itself their defender.

That, in two words, is the cause of the present conflict.

On certain sides, the labor syndicates seem to decide in favor of the partisans of the return to the old corporative idea. Presently, in fact, and as soon as we step into the Exchange we shall meet with the masterpiece of yore, the capital piece that is carried in procession, and that is exhibited as a material proof of the skill and of the excellence of the corporation's work. In the parvises, too, we read upon the placards the insertion of the name of a laborer in the index expurgatory by the syndicate—the pillory such as it was formerly understood in the wardenships and masterships.

Finally, through the trade union, that professional freemasonry, we are still farther back in that corporative middle age from which one claims to have freed himself. But, on another hand, the syndicate offers us entirely modern glimpses when it shows us the laborer, under the pretext of liberty, sleeping in the same room with others, matriculated, and regimented, having replaced the foreman of the factory, shop, or works by the leader of the club, whose authority he recognizes and blindly follows; hypnotized finally by the perpetual idea of the fight against "bloated capital;" all this enveloped in the folds of a politics unknown to the corporations of old, and which overcomes him unbeknown to himself, although he defends himself against it and which is the true corporative flag flapping red in the wind of riot.

The Labor Exchange, of which we are going to speak, is the quintessence, the *resume* of the syndical organization. The practical object of it is to unite the syndicates, to facilitate the hiring of laborers by employers, without the intermedium of employment agencies, to put *en rapport* the requests for and offers of situations, to establish relations between the groups of local wage earners and those of Paris, the provinces and foreign countries; to enlighten them as to strikes, to found syndicates by propaganda, and to occupy itself with corporative and social statistics, questions of solidarity, and, in a word, all that concerns the emancipation of the workman.

Under such circumstances it is, therefore, the central point, the institution recognized by laborers as being the sole social organization truly representing the corporative, economical, and humanitarian interests of all wage earners.

The idea realized to-day is not new. As long ago as 1790, the general assembly of the representatives of the commune of Paris voted the principle of it for replacing the places of strikes, that is to say, the suburban and open places where the laborer stayed from morning till night waiting to be hired.

In the beginning, the Labor Exchange was, therefore, a simple shed shielding the laborer from the inclemency of the season, and creating for him, upon the whole, an employment agency. It was under such conditions that the question was in 1851 carried to the legislative assembly by Mr. Ducoux, the representative of the people, but defeated by 413 votes against 218, out of 631 voters.

In 1868 the laborers delegated to the Exposition of the following year made it the object of a report and petition, but it was not till 1875 that the practical period was to begin.

The Municipal Council then took it up officially, discussed at length, for several years, the questions of the labor shelters and employment offices disseminated through various quarters, and finally decided upon the creation of an exchange upon the proposition of Mr. Mesureur, Mr. Floquet being prefect of the Seine.

The old Masonic premises of Jean Jacques Rousseau Street served as the first refuge for the syndicates. The inauguration took place on February 3, 1887, and, on July 4 of the same year, 158 syndical chambers and labor groups took definite possession of it.

This building was at once called Annex A, for the funds were already on hand for the construction of a central exchange on Chateau d'Eau Street (Place de la Republique). This latter, which we are going more particularly to describe, was finished and officially inaugurated on May 22, 1892. It shelters at present 213 syndicates, which have therein offices, a library, conference halls, halls for public meetings, etc. The syndicates that are admitted thereto have everything free—heat, light, and furniture are given gratuitously and paid for out of a fund of 42,000 francs, voted annually by the Municipal Council. It is useless to add that the Labor Exchange has its complete autonomy, that it is free from interference of any kind whatever by the city or state, save, of course, in that which concerns the vote and the approbation of the budget, and that it is administered by a central committee composed of delegates elected from all the associate syndicates, which is subdivided into directing sub-committees of such or such a service, and appoints an executive commission of administration.

Let us stop a moment in front of the façade. It is monumental with its six stories, with regular rows of windows and its beautiful doors. Dressed stone, iron and solid oak, the strongest materials, enter into the construction of this asylum of militant labor; nothing has been spared therein. The entire edifice cost nearly two million francs, and in front of it strolls the melancholy policeman representing the last vestige of that law which is not made for those inside.

Let us enter: a superb *parvise*. To the left, the porter, to the right, the adminstration or permanent seat of a delegate or secretary of the directing central committee. There are seven, of which the following are the names and functions that indicate to us the mechanism of the commissioners: Beaumé (administration), Lhermite (correspondence, accounts and finances), Galimardet (statistics and strikes), Rossignol (treasurer), Bernard (secretary of Annex A), Pitance (propaganda) and Gile (librarian).

Immediately upon entering, we see upon the wall on each side the bill boards, to which we have already alluded. A profound quietness reigns in the hall; scarcely a murmur under the vaults, interrupted suddenly by a "gust" of clamors that has entered through an open door, and that proves that the quietness is only apparent.

On each side of the peristyle staircases ascend to the upper stories and give access to the bodies of the building, which are arranged in a square around a central court, which is itself covered and converted into an admirable hall for the great syndical or public reunions. The walls of this hall are frescoed, benches of solid oak are found everywhere, and in the rear there is a monumental stage. A plaster effigy of the republic, with a red scarf, presides.

The assembly room is capable of accommodating about four thousand persons. Beneath it, under the flooring of thick glass, among the foundations of the edifice, opens yawningly the hall of strikes, which, too, is capable of accommodating about four thousand persons. Here, morning and evening, meetings are held for creating a perpetual agitation and accustoming the laborer to speak in public as in a parliament of the Fourth State.

Let us now ascend to the various stories. Upon corridors that extend all around the structure open the doors of the bureaux wherein the syndicates have their own furniture. Here a few members daily meet in rotation, so as to constitute what are called *permanences*, where at any moment of the day or evening the isolated laborer may come to have an understanding or to complain, or to take or bring orders.

One of the most important permanences is that of the railway syndicate, the greatest of the syndicates belonging to the Labor Exchange.

It consists of two large rooms of administrative and plain appearance, provided with writing tables and sets of pigeonholes. The keeping of books, accounts and cash, the sending of summonses, the preparation of the mail, the editing of the proceedings, the receiving and classifying of complaints (which will be examined), such are the duties of the members of the permanences.

There is here, truly, a power. A simple word of order sent hence, a telegram, and to-morrow an entire railway force will be on a strike, and will submit passively without even asking why, just as the coachmen have just done, and just as so many others do every day.

Let us ascend again, and as far as to the sixth story, and everywhere, in every nook and cranny, we shall find syndicates at work, we shall hear the sound of voices behind the doors, and if we lean out of one of the windows looking upon the central court, we shall obtain a good idea of the whole of that fatal funnel into which, thus organized, the world of labor is descending.

At the sides, the *permanences* that prepare and discuss; in the center, the public hall in which the resolutions taken are cheered; and, beneath, that mysterious cellar of strikes in which all the staircases of the building end as the last degree of resistance, the *ultima ratio* of labor against capital.

Let us cast a glance, in passing, at certain annexes of the exchange, the library, for example, a very pretty little hall where we shall meet with one of the corporative masterpieces of which we have spoken—a chimney piece with all its furnishings, chandeliers and clock of imitation marble. It is truly a superb piece of work, the whole of which would be worth

THE LABOR EXCHANGE—LIBRARY.

commercially six or eight thousand francs. Let us note also the conference halls with their blackboards and projectors.

France possesses at present thirty labor exchanges. . . . We have now rapidly shown in its broad lines one of the corners of the professional organization of the Fourth State. It has just been born officially, and has its own furniture. Its Fourth State programme is all contained, for him who wishes to read between the lines, in the heading of the map of the syndicates, viz.: "The emancipation of laborers can be the work only of the laborers themselves."

It is the conquest of power and its practice by the laborers to their profit. We have seen the economic means that they employ to arrive at this syndication and then strikes, which, from particular and local, become general and universal as soon as things are ready.

Then will occur the sudden rupture, on the same day and at the same hour, in the entire world, of the relations of labor with capital. Up to the present, we have had theoretical firsts of May, so to speak; soon we shall have practical ones. It will be the labor propaganda in fact, the definitive work of the Labor Exchange and the syndicates.—*L'Illustration.*

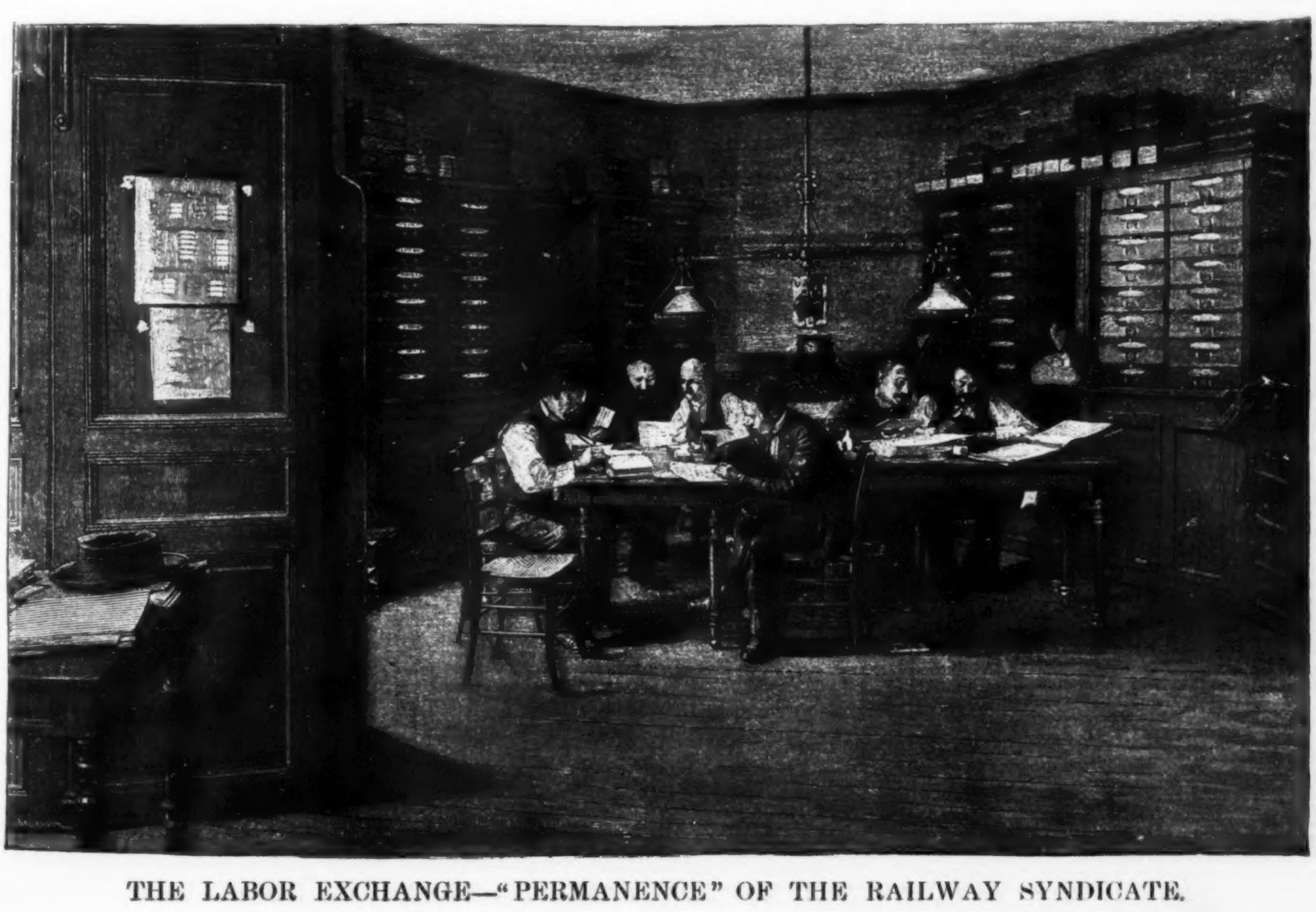
MAGNESIA BRICKS.

For the manufacture of magnesia bricks, the material most in favor at present is the magnesite of the Veitschthal, in Styria, which, although less pure considered as a source of magnesia than the same mineral from the island of Eubœa, in the Greek Archipelago, has nevertheless the property of fritting at a high temperature without melting. This is due to the presence of iron and, probably, alumina in small quantity. The composition of the two substances, both in the natural and burnt states, is as follows:

MAGNESITE.

	Styrian.	Greek.
	Per cent.	Per cent.
Carbonate of magnesia....	90·0 to 96·0	94·46
" lime........	0·5 to 2·0	4·40
" iron........	3·0 to 6·0	FeO 0·08
Silica....................	1·0	0·52
Manganous oxide..........	0·5	Watr0·54
Calcined Magnesite.		
Magnesia..................	77·6	82·46—95·36
Lime......................	7·3	0·83—10·92
Alumina and ferric oxide	13·0	0·56— 3·54
Silica....................	1·2	0·73— 7·98

The calcination is effected in cupolas with a silicious lining, in reverberatory furnaces, or, best, in highly heated gas kilns, the nature of the product varying with the amount of heat to which it is subjected. At a red heat magnesium carbonate is decomposed into carbonic acid and caustic magnesia, which resembles lime in becoming hydrated and recarbonated when exposed to the air, and possesses a certain plasticity, so that it can be moulded when subjected to a heavy pressure. By long continued or stronger heating the material becomes dead burnt, giving a form of magnesia of high density, sp. g. 3·8, as compared with 3·0 in the plastic form, which is perfectly unalterable in the air but entirely devoid of plasticity. According to Schlossing, a mixture of two volumes of dead burnt with one of plastic magnesia can be moulded into bricks which contract but little in firing. Other binding materials that have been used are clay up to 10 or 15 per cent., gas tar, perfectly freed from water, soda, silica, vinegar as a solution of magnesium acetate which is readily decomposed by heat, and carbonates of alkalies or lime. Among magnesium compounds a weak solution of magnesium chloride may also be used. For setting the bricks, lightly burnt, caustic



THE LABOR EXCHANGE—"PERMANENCE" OF THE RAILWAY SYNDICATE.

magnesia, with a small proportion of silica torend er it less refractory, is recommended. The strength of the bricks may be increased by adding iron, either as oxide or silicate. If a porous product is required, sawdust or starch may be added to the mixture. When dead burnt magnesia is used alone, soda is said to be the best binding material. According to Lezius, the average composition of magnesia bricks in use is about—magnesia, 80·9; silica, 4·8; alumina, 1·6; ferric oxide, 6·8; lime, 6·5 per cent. When a magnesia brick is laid upon a fire brick bed, no action takes place below about 1,600° C., but above that point combination takes place with the formation of a fluid gray slag, which rapidly perforates the fire brick. When a bed of pure alumina is used the resistance is somewhat greater, but not much. The resistance to slagging from the ash of fuel is only about one-half that of a good fire clay brick. Upon a coke or gas carbon bed, pure magnesia may be heated higher than the melting point of platinum without showing the slightest sign of fusion, but in the presence of other substances, fusible combinations are more or less readily formed. The fluxing power of these substances is as follows in ascending order: Alumina, lime, ferric oxide, silica, and phosphoric acid, the latter substance being far more corrosive in effect than silica. A mixture of pure alumina and magnesia in equal parts is infusible at the welding point of malleable iron, but the combination is rendered easy by the presence of a third oxide.

In addition to their principal application in the basic open hearth furnace and converter, magnesia bricks have been successfully used for lining kilns for cement making and in burning strontia for sugar works, and also in lead and antimony smelting works, as they remain perfectly tight when exposed to molten lead, which readily permeates ordinary fire bricks.—*C. Bischoff.*

ARSENIC WORKS ON THE TAMAR.

By S. BARING-GOULD.

A SPUR of hill, covered with oak coppice, about which the River Tamar forms a loop, in one of the loveliest parts of that lovely river—the spur called Blanch Down—had attracted the attention of mining speculators during the early part of the present century. Money had been collected and spent there without result other than of exhausting the pockets of the shareholders, when, with great difficulty, a fresh company was formed in 1844 to make another attempt to tap the suspected treasures of Blanch Down. Some miners descended the abandoned shaft down which had gone the money of preceding adventurers; and only nine feet below the point at which the mine had been abandoned they struck on one of the finest lodes of copper ore ever discovered. It was thirty feet wide and a mile in length. At the end of ten months the company divided 70,000*l.* That was the story of the Devon Great Consols.

For twenty-eight years this proved the richest mine in the country; then the lode gave out, yielding in very reduced proportions, and it would have been abandoned before this had not the waste thrown out as worthless when copper was sought proved rich in arsenic. The Devon Great Consols is now resolved into arsenic works. Copper is still raised, but in comparatively small amount, and is dispatched to South Wales, there to be smelted. As it takes four tons of coal to smelt one ton of copper, it is obviously advisable to carry the ore to the coals, and not bring the coals to the ore.

Along with the copper ore, vast quantities of mundic were found, and thrown away. Mundic is iron pyrites; and the arsenical pyrites consist of 25 to 30 per cent. of iron, 12½ to 14 per cent. of arsenic, and the rest earthy matter, locally termed *caple.*

The material brought up from underground is crushed in a machine called the stone breaker that resembles a huge pair of jaws, which literally chews up the stone till it has reduced its proportions sufficiently to pass into a second machine, the crusher, wherein it is pounded into pieces about the size of a walnut. The material is now conveyed in barrows to the dressing floors, and each barrow load is turned out and washed in a running stream that carries off the small particles. The nuts are then thrown up with a fork upon a table, behind which recline, on a sloping board, the bâl maidens. "Bâl" is the Cornish for "mine," and has nothing to do with Baal, the Phenician deity, as certain wiseacres would have it, any more than has Ball's Pond near London.

The girls lie on the inclined board, with their elbows resting on the table, and they rapidly sort the pieces thrown to them by the bâl boys. On each side of the table are three wooden boxes, and before them is a trough. Into the trough they cast the specimens of copper—into the first side box, the arsenical mundic; into the second, the "elvan" (inferior matter); into the third box, the rubbish. They sort with an iron scraper, but use largely their fingers. As they work they sing in parts; they are merry, light-hearted girls and generally well conducted; their age is from thirteen to sixteen. Unhappily, the old romantic ballads of interminable length, to grand old melodies dating back to the middle ages, have been gradually abandoned for hymns and music hall songs, and now among the young bâl maidens there are hardly any who can sing the old songs that were the delight of their grandmothers and great-grandmothers. In the matter of poetry and music, they have collected the rubbish and rejected the fine ore.

The wash from the crushed stone is carried by the water to the "jiggers," a machine that shakes and sifts it.

After being jigged, the small stuff is washed in "strips," when the deposits are left in the following order: Mundic comes first as heaviest, then copper ore, and, lastly, rubbish; which, however, is not rejected till it has been again jigged. All the better class of mundic from the crushers goes at once to the furnaces, the inferior is sent to the jiggers, and jigged and jigged till everything refuse is washed away, and all that is good retained.

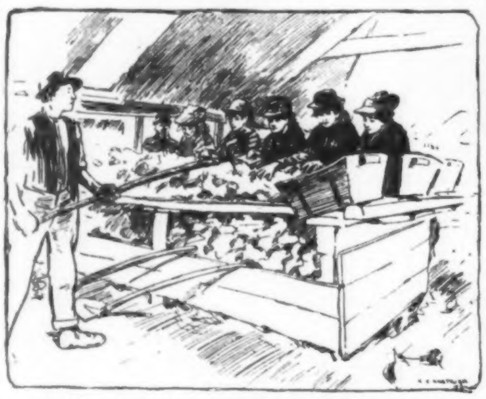
As soon as the arsenical pyrites is completely separated from the common ore and from the earthy matter, then it is conveyed to the first calciner, where it is burnt with low class coal, and produces "arsenic soot;" that is to say, arsenic so mixed with smoke soot from the coal as to be of a gray color. The arsenic and soot are deposited combined in the chimney or condenser. This is scraped out and taken to the second calciners to be purified.

There are two very striking calciners in use; one is a vast drum of iron with phalanges or fins inside. A fire of anthracite coal is carried through this drum, which is in revolution. The arsenical soot is admitted,

AN ARSENIC FURNACE AND WORKERS.

and is burnt in the glowing heat within the drum, and turned over and over at each revolution by the phalanges till thoroughly consumed and transformed into vapor, when it is carried off up the chimney condenser.

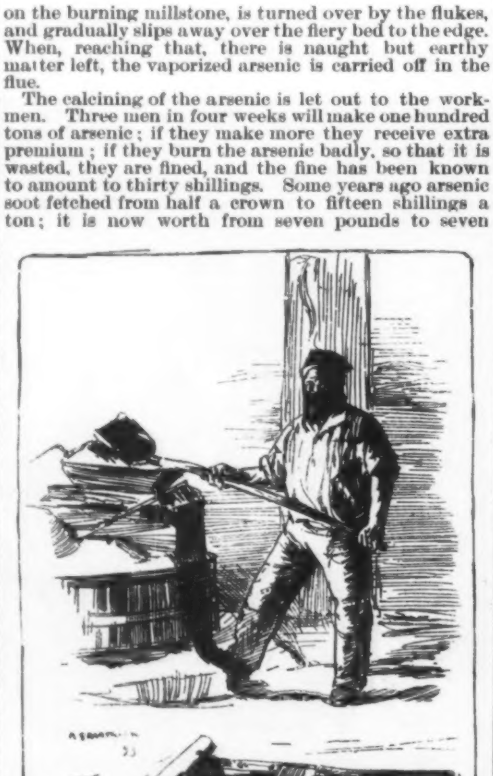
The second method consists of a rotary iron, like a millstone, convex in the middle, under a surface studded with iron flukes in three ranges, five in each. The arsenic to be refined is admitted from above. A fire is kept up in a furnace at one side, and the flames are swept in between the rotating millstone and its fluke-studded cover. All are brought to a glowing red heat. The arsenic on falling in blazes as stars, and dropping



BAL MAIDENS SORTING MUNDIC AND COPPER ORE.

on the burning millstone, is turned over by the flukes, and gradually slips away over the fiery bed to the edge. When, reaching that, there is naught but earthy matter left, the vaporized arsenic is carried off in the flue.

The calcining of the arsenic is let out to the workmen. Three men in four weeks will make one hundred tons of arsenic; if they make more they receive extra premium; if they burn the arsenic badly, so that it is wasted, they are fined, and the fine has been known to amount to thirty shillings. Some years ago arsenic soot fetched from half a crown to fifteen shillings a ton; it is now worth from seven pounds to seven



AN ARSENIC MILL AND FEEDER.

pounds ten shillings. The arsenic is refined till it is, to use the local term, "as white as a hound's tooth."

It is deposited in the condensers. These are neither more nor less than a mile of chimney carried on an incline up the hill, with doors of iron in the side. As the hot blast passes up the chimney, it deposits a crust of arsenic crystals on the brickwork all round to the depth of from two to three inches, and it deposits minute dust of crystals on the floor. Before the smoke passes into the upright chimney, the height of which is 125 feet, it has to traverse a rain of water which catches what remains of the arsenic, after which what passes forth is nothing but sulphurous acid.

The crystals of arsenic are scraped out of the flue, or condenser, while still warm, and are ground in a mill to flour of arsenic, after which it is packed in small barrels, containing a little over three hundredweight.

The men who work the arsenic, either raking up the arsenic soot, or scraping out the condensers, or grinding it in the mill, are obliged to wear mufflers over their mouths and noses, to prevent inhaling the particles. The arsenic workers are obliged to wash themselves thoroughly every day on returning from the works, as the arsenic is liable to produce sores wherever it lodges in wrinkles and folds of the flesh, especially about the mouth and nostrils, the wrists and ankles, and under the arms—in fact, wherever perspiration lodges. As a rule it only does this when the worker is careless about his personal cleanliness. Otherwise the work is healthy, it prevents all eczema; and the fumes of sulphurous acid, as well as the arsenical dust, are fatal to the germs of disease—such as scarlet fever. Eventually the workmen may come to suffer from the chronic arsenical symptoms, which are—loss of appetite, silvery coating to the tongue, nausea, frontal headache, languor, sleeplessness, and anæmia. When that is the case, they have to give up the work entirely, but many remain at the works for a great many years without suffering; but these are men who have been scrupulous about their personal cleanliness, and have not been careless concerning their mufflers.

The vapor of the burning pyrites contains not arsenic only, but also sulphur, the iron cinder is cast away, the arsenic is condensed; by the time the upright shaft is reached, the vapor is reduced almost entirely to sulphurous acid. The water flowing away from the chimney is like soapy water, so charged is it with sulphur, and the fume blasts the vegetation for some distance round, making Blanch Down an eyesore in the landscape.

When the upright shaft has to be entered, for one purpose or another, the effect on the eyes is most painful—it is as though they were smitten with vitriol. The men wear linen garments lined with flannel, and the sulphuric acid fume will completely destroy the linen in a few moments, leaving the flannel intact, so that the men go into the shaft in linen and come out clad in wool. Happily the necessity for entering the shaft is not of frequent occurrence, or they would lose their sight.—*The Graphic, London.*

HOW TO TEST THE FINISH OF A CLOTH.

IF it is desired to find out what treatment has been adopted in the finishing of a cloth, a sample should first of all be examined to ascertain whether it was lustered, calendered or sized on one or both sides, and by looking through it, it will easily be seen whether it was sized only or sized and weighted, and how. If it was heavily sized, it is hard to the feel, but becomes softer as it is rubbed between the fingers, and if a sizing with weighting was used, dust will fly from the material when it is being torn. By using a strong magnifying glass, it may be ascertained whether the finishing agents lie only on the surface of the fabric or have penetrated the body of the cloth, and also if mineral substances have been employed in their composition. The external appearance of the cloth will enable an expert to judge the kind of finish and the hygroscopic percentage must be ascertained. A sample of the material must be weighted and left in a drying box until a decrease of weight is no longer noticeable; this, however, does not indicate certainly the nature of the finish, but a great decrease in weight does denote a good percentage of finish.

To find the quantity of finish in the cloth, a weighed sample is washed in distilled water containing malt, and dried, and then weighed again. The difference in the weight tells how much starch, dextrine, etc., there was in the piece. To test the cloth for the percentage of *soap* in the finish, the sample is boiled in water, passed through boiling acid, washed, dried and weighed. The loss shows the quantity of finish, if the sample is not dyed, for which a treatment with acid can only be used. After having ascertained the percentage of dry finishing, the qualitative analysis must be made. This consists of two operations. Boil the sample for several hours in water to remove the starch, starch preparations, gum, soluble metal chlorides and sulphates, as well as the mineral constituents. After filtering, a portion of the clear fluid must be evaporated; then add tincture of iodine, which betrays the presence of starch. If this reaction does not occur, continue the evaporation and add three times the quantity of alcohol, by which dextrine and gum are separated from the solution.

Glue and gelatine may be determined with a tannin solution. To distinguish the gum from the dextrine, the polarizing instruments are used, when dextrine rotates to the right and gum to the left. If both are present, they may be separated with basic acetate of lead, by which gum is separated in cold from the solution. If no precipitate is thus obtained, but a black coal results by heating the evaporated fluid upon the sheet of platinum, it is owing to a percentage of mucilage of Iceland moss contained in the finish. Sugar is detected with Fehling's fluid. To test the filtered liquid for soluble mineral salts, the ordinary process of the qualitative analysis is employed, and that which remains upon the filter generally is China clay, or sometimes gypsum or lime.

Colophony (bright resin) is recognized by boiling a sample with soda, when a soluble resin soap is formed, which, when mixed with an acid, gives a precipitate of sylvinic acid, while the soap formed from fat separates the fatty acid as a layer of oil floating on the fluid. In order to ascertain what fat it is, treat a cutting of the sample with ether, which takes up all the fat, and by dissipating the ether, the whole percentage of fat in the finishing is obtained. Further than this the practical manager cannot go; he must be satisfied with the boiling in water. It is unnecessary when determining a finish to know the quantity of the

ingredients. To ascertain what they are provides him with sufficient data for composing a similar finish.—*Leipziger Monatschrift fur Textil Industrie.*

INSULATORS FOR HIGH VOLTAGE.

EXPERIENCE has shown that the best insulators for high voltage bare cables, carried on poles, are those in which surface leakage is prevented by a bath of highly insulating oil. There are various forms of these. One of the most common is shown in Fig. 1, and consists of a single-bell porcelain insulator, with the bell formed into an annular channel to hold the oil. This form is open to the objection that insects may weave their webs across the top of the oil channel, thereby reducing the insulation resistance to a very small figure

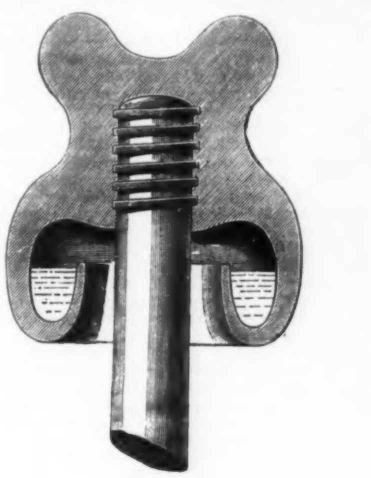


FIG. 1.

when the webs are damp with rain or dew. The insulator used on the Tivoli-Rome high-pressure line is superior in this respect, since the oil is quite inclosed. A diagram of this insulator is given in Fig. 2, in which A is an ordinary double-bell porcelain insulator and B is an adjustable insulator of the same material capable of carrying oil in an annular cavity, C. When the lower insulator is pushed up into its proper place, the inner bell of the upper insulator dips into the oil, as shown, and effectually prevents accumulations of foreign matter from short-circuiting it. The oil must be heavy and non-volatile. Resinous oils have been found to be the most serviceable. On this particular line, between Tivoli and Rome, there are four stranded copper cables, each 100 square millimeters in section and capable of carrying 120 amperes. The length of the line is 25 kilometers, and poles are arranged 35 meters apart. Each pole is 30 ft. high, and is constructed of wrought iron. There is a loss of 1,000 volts in transmission, the drop being from 5,000 volts at Tivoli to 4,000 at Rome.

Special forms of lighting guards are necessary on all overhead lines which are worked at high voltage. Ordinary telegraph guards may suffice where the voltage is very low, but currents at high voltages would continuously arc from the line to earth through the ordinary guard when once the lightning has passed a spark between the two. The principle of all such guards is that the ordinary pressure of the line is not sufficient to pass a spark across the air gap which forms the guard, while the intense pressure of the lightning flash will prefer to establish a spark rather than face the high self-induction of the line and machines. The lightning, in passing across the air gap, volatilizes some of the metal of the electrodes, and thus enables a high pressure current to *keep up* an arc across the air gap which is sufficient to destroy the line. One of the most successful lightning guards for

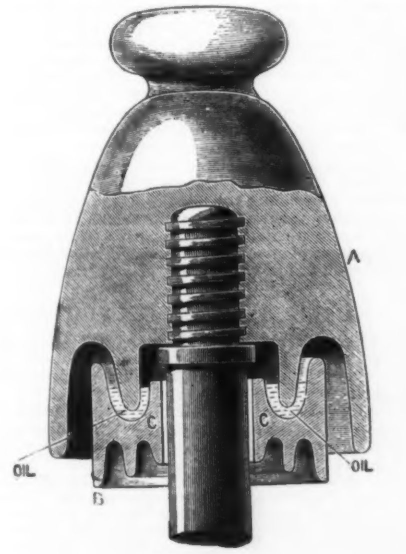


FIG. 2.

high-pressure lines is that invented by Prof. Thomson, of the Thomson-Houston Company. This is shown in Fig. 3, and consists of two curved metallic electrodes, L and E, which are so shaped and placed that there is a continually increasing air gap from the bottom to the top. The bottom of the air gap is placed between two elongated pole pieces of an electro-magnet, M, which is continuously excited by the current in the line. The connections are as shown in the diagram, one of these guards being placed in each line, between the line and the dynamo terminal. Whenever a flash of lightning strikes either the forward or return line, a spark is established between the metal electrodes, L and E, and will naturally pass between the points where they are closest together. Being in a strong magnetic field, the spark is acted on by a repelling force, which drives it out of the field. But before the spark can have quite left the field between the pole pieces the distance across the air gap is too great for the line to keep up a current, so that the spark goes

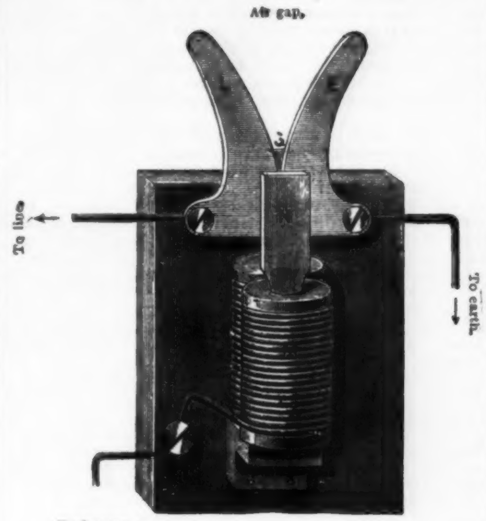


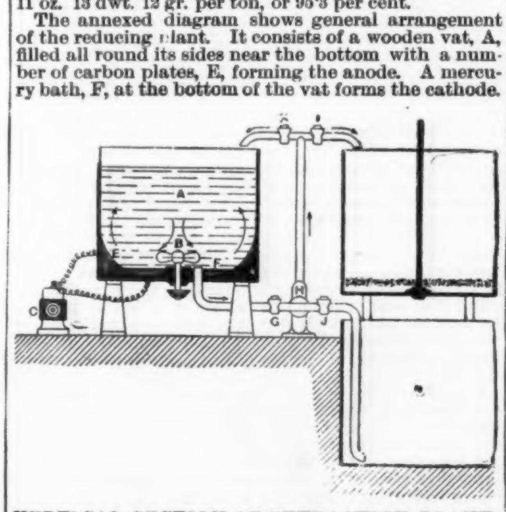
FIG. 3.

out—is blown out, in fact, by the magnetic field. When the line is not working, a lightning flash will simply pass across the gap, as in an ordinary guard, and no continuous arc will be established, so that the magnetic field is not required. The earthing wire must have a carrying capacity and mechanical strength equal to that of seven strand No. 16 galvanized iron wire, and should be attached to a metal plate buried in the ground at a depth of not less than three feet. The area of the earth plate must be at least four square feet. Instead of an earth plate, metallic pipes for water supply, if outside of buildings, may be used. —*Electrical Review.*

THE ELECTROLYTIC EXTRACTION OF GOLD.

A PAPER was recently read by Mr. J. B. Hannay, at the Institution of Mining and Metallurgy, upon a method which he has brought out for the extraction of gold from various states of ore by means of an electric current. Since the reading of this paper we have had an opportunity to examine the extraction plant and the working of the process. Briefly stated, the principle of the process is this: The combination of an electrolysis of a gold cyanide with the amalgamation of metallic gold; that is to say, the process consists in the addition to the ordinary mechanical washing and amalgamation of an auxiliary electro-chemical process, whereby the gold which is not directly amalgamated out is dissolved in a soluble cyanide, such as potassium cyanide, and is subsequently deposited on the mercury cathode from the electrolytic salt of gold thus formed. The process is essentially twofold, and on this account it is claimed that it will insure a more perfect extraction of gold than in the simple amalgam process. As an example of the yield of gold by this electro-cyanide process, we may quote the figures given in the case of the Maritoto ore by Mr. Fred. Claudet. The assay of this ore indicated 12 oz. 5 dwt. of gold per ton, and subjection to the process we have described gave a yield of 11 oz. 13 dwt. 12 gr. per ton, or 95·3 per cent.

The annexed diagram shows general arrangement of the reducing plant. It consists of a wooden vat, A, filled all round its sides near the bottom with a number of carbon plates, E, forming the anode. A mercury bath, F, at the bottom of the vat forms the cathode.



VERTICAL SECTION OF EXTRACTION PLANT.

Dilute aqueous solution of potassium cyanide is poured into the vat, and the ore, which has previously been crushed, but not roasted, is added. The thick, muddy liquid thus formed is kept in circulation by the mechanically propelled screw, B. An electrolyzing current is generated by the small dynamo, C. The ore circulates in the direction of the arrows, with the result that the free gold is directly amalgamated out, while the refractory gold ore is dissolved by the cyanide, forming a double cyanide of gold and potassium. This double cyanide is very shortly reduced to metallic gold and the simple cyanide of potassium, by the electric current. Thus it will be seen that the process is cyclic in its action; the limited quantity of cyanide serving to reduce an unlimited amount of ore. In from two to six hours the charge has been exhausted. The valves, G and I, are opened and the centrifugal pump, H, is set in action, transferring the liquid from the working vat, A, to the filtering vat, L. Here the liquid cyanide filters into the receiver, N, while the sludge is retained in L. To operate on another charge of ore, it is only necessary to close the valves, G and I, and to open J and K, when the filtered cyanide of potassium will be returned to the working vat, and the whole cycle of operations may be repeated. It should be mentioned that the earliest patents, under which Mr. Hannay is working his process, date back to 1886. —*Electrician.*

[Continued from SUPPLEMENT, No. 920, page 14701.]

THE IDEAL ENGINEERING EDUCATION.*

By Prof. WILLIAM H. BURR, of Columbia College, New York.

THE application of steam to industrial purposes, more especially in the steam engine, received its most powerful impulse through the scientific work (both analytical and experimental) of Rankine, Clausius, Joule, Hirn, and others; and the conditions of development of steam power in later years have been in strict accordance with the lines marked out by abstract scientific study. There is, however, no department of the natural philosophy of engineering in which the higher branches of physical study have been so essential to the advance of practical engineering work as in that of electricity and magnetism. Indeed, it may be said that there could be no electrical engineering without the most advanced mathematical and physical study in electro-statics and electro-dynamics. It is within my personal knowledge that during the past year two among the largest in this country of what may be called electrical engineering companies have applied to at least one engineering school for a number of electrical engineers equipped with a mathematical and physical training materially beyond that afforded by any four years' course of study now established in this country, and that equipment was made an indispensable condition for the offer of the unusually large salaries which accompanied the request.

There are portions of the field of electrical engineering in which a most profound theoretical knowledge of electricity and magnetism is quite necessary to a competent discharge of the practical duties involved. If it were necessary to add force to what I have already said, I would only mention the contributions to practical work which have so frequently been rendered by Lord Kelvin, and made possible only by his incomparably profound theoretical knowledge. I think, however, that the argument for the second essential of the ideal engineering education may rest, and that it may be confidently stated that it consists of a most thorough mathematical and physical training; but adapted in its entire matter and method to the subsequent engineering practice.

One of the most important considerations in connection with the educational training of an engineer is that of the introduction of actual engineering operations, as far as practicable, into the course of study. I do not mean by this the experimental portion of the instruction in the physical sciences, for it is included under the general head of that instruction; but I refer to workshop and laboratory practice, instrumental and other field work involved in railway, geodetic and other surveying operations, the actual design of engineering works, including specifications and estimates, visits of inspection and observation to works in process of construction, as well as to those completed and in use or in operation, and office practice and organization in its varied character and manifold functions. It is at once clear that these classes of work should be included in some degree, and that they should be required consistently with the special field of practice elected by the student. In civil engineering he may, without essential prejudice, omit all workshop practice, although he is clearly better off with an acquaintance with its elements; but he needs and must have laboratory practice in the testing of materials and in such hydraulic operations as lend themselves to that mode of treatment. It is, again, imperative that he have thorough drill in instrumental and other field work involved in all surveying operations. This is the more important for the reason that it forms a class of duties which it is very probable he will be required to perform at the beginning of his practice, and which, after a few years, with their promotions in the natural order of things, he will lay aside for others more advanced. The mechanical and electrical engineers, on the other hand, require thorough courses in both workshop and laboratory practice, but they should omit the courses in instrumental work and field operations of surveying. The mining engineer again needs the latter and the laboratory practice, but he may well take the elements only of workshop practice. All students in engineering require as much time devoted to specifications, designs, and estimates; trips of inspection, and to office practice and organization in their respective applications to each speciality as a proper consideration of other essentials will permit. All these generalities, I presume, every one will admit, but there is room for great diversity of opinion in reference to the weight or relative importance to be attached to each division of this part of the educational work, as compared with others of the same course, and in reference to its position in time within the possible assignable limits. In the consideration of the relative weight or importance of these divisions, it should be observed with emphasis and borne in mind with the greatest care that no education in engineering, ideal or otherwise, ever made a practitioner, or ever will, but the best education is that which will prepare the average young man possessing the proper natural endowments to rise in practice to the highest professional plane. It can neither force into

* Read before the Engineering Congress, Chicago, 1893.

him what nature has failed to bestow nor can it equip him with what only experience, which is second nature, can supply; the latter is just as impossible as the former. That being the case, it is clearly the function of the technical or professional school to give him all that fundamental scholarly training in principles which practical experience cannot supply; this is the chief end to be attained in the educational life of the young engineer, for it is his last opportunity to secure it.

The urgent demands upon the time and efforts of the young practitioner leave little or no opportunity and less inclination for study, and it is almost certain that deficiencies in the field of study will never be remedied in active life. Any defect in the purely practical part of his education can, at the most, but slightly hamper him at the very beginning, only, of his career, and is soon remedied in the natural order of his experience; while, at the best, those same practical parts of his educational training can be but imperfectly taught prior to his actual contact with the things themselves. Practical impressions received under the unreal conditions of instruction may indeed be more or less sharp and complete, and correspondingly valuable, but any one who assumes to successfully substitute them for the effects of real practice will disappoint others, even if he does not disappoint himself. Indeed, misdirected efforts of this character can scarcely be saved from miscarriage; there will be a certain failure to produce a ready-made practitioner and the strongest probability of generating a sort of "wind-fall" young engineer, the scope of whose usefulness and ambition will be confined to a callow excellence in the clerical or office technique, which, it is true, brings quick employment after graduation, but just as slow ultimate promotion. Those efforts form a sort of forcing system, which seems prematurely to exhaust or destroy essentially all that power of further growth or development that proceeds naturally, albeit slowly, from a more scholarly preparation followed by a better balanced and well rounded practice. These considerations indicate, in general, a place for the purely practical matters in the curriculum of the professional school supplementary to, and not co-ordinate with, what may be designated the rational part. I do not necessarily mean supplementary in point of time, but in point of relative importance or weight. I regard them as absolutely essential to an efficient course of study in engineering, but in estimating their relative weights in the curriculum, they must take places subordinate to the study of principles. The assignment of time and effort should be such, therefore, as to accomplish the study of principles in the most thorough manner, and the accomplishment of the purely practical work should be made consistent with that end. It should not be the aim to perfect students in that craft skill which they will in general be called upon to exercise at most but sparingly. Their functions as engineers will require of them, in the main, a close familiarity with the methods of mechanical performance, but not with the performance itself. I do not mean to assert that the young engineer will not frequently at the beginning of his practice be required to make a craftsman's experience a part of his own; he probably will, and often should do so, and portions of his education should fit him for such duties; but that is not the ultimate end or aim of the course of study indicated by the curriculum; it is far above and beyond that.

The time and attention given to those mechanical or routine portions of the course of study in engineering which may be termed the purely practical parts, should be so applied as to thoroughly acquaint the student with methods, and only so much craft skill in them is requisite as is necessary to that end. This general principle, which I regard the third essential characteristic of the ideal engineering education, must be applied to each specialty in engineering consistently with its chief purposes. The mechanical engineering student must take a comparatively large amount of workshop practice, but it must be for the training of a mechanical engineer, and not for the purpose of attaining the skill of a mechanic. The student in civil engineering must acquire a high order of facility in the use of surveying instruments, but it must be adapted to his career as an engineer, and not as a surveyor; and essentially the same observation may be applied to the instrumental work of the mining engineer. Indeed, the principle is perfectly general, and may be applied to each division of purely practical work in each specialty. The student should attain to that degree of excellence which will enable him at the end of his course of study to make a fair and reasonable connection with the beginnings of his professional career; the professional school cannot qualify him to do more, and he should not be content to do less. There is, again, a possible range in opinion as to the proper place in time for the introduction of these practical or routine matters. They may either precede or follow or be concurrent with the abstract scientific studies to which they are related more or less closely. It seems to me that a careful consideration of the things involved will inevitably lead to the conclusion that all these relative positions must be employed. Familiarity with the physical characteristics and uses of tools, machines, simple mechanical processes, instruments, and apparatus cannot be acquired too soon. For this reason, workshop practice should be commenced at the beginning of the course of study, and it should be continued without break, if possible, until the end of the period allotted to it. I am inclined to believe that a reasonable number of hours per week will permit this part of any course in mechanical or electrical engineering, if pursued continuously, to be completed within one and a half to two years. If civil and mining engineer students should elect any work of this character, a half of that period at most will be sufficient for their purposes. This disposition of time for the purely mechanical or craft part of the student's work will give him a very appropriate and efficient preparation for the extension of the advanced branches of engineering physics in the fields of testing and research, which must, of necessity, be the work of the latter part of the course of study. The skill in mechanical manipulation requisite for the best quality of such advanced laboratory work as the testing and rating of steam engines and boilers, hydraulic motors, and other prime movers, as well as dynamos and other electric motors, the investigation of methods and devices for the transmission of energy, and for all other similar work, will thus be acquired in logical priority to the time of the student's need. These portions will either be concurrent with or follow their analytical or theoretical treatment, as the nature of their various details may make advisable. The same order of procedure should be followed in the more elementary laboratory work of the physical testing of materials and hydraulic gauging, so far as the latter can be treated without field work; little or none of these divisions of the student's operations should precede the rational treatment. While it is undoubtedly true that there are some features of illustrative experimental work which are quite independent of the abstract principles involved, it is just as true that it is impossible to completely and accurately interpret them without a knowledge of those principles, and there are very few cases indeed where the study of the latter should not at least be concurrent with the experiment, and it should usually be precedent.

All field work of surveying and other geodetic operations, the gauging of rivers and canals, visits of inspection and for the purpose of reports, all of which involve the application of principles in the performance of specific duties, must necessarily be preceded by a thorough study of those principles, and by the acquisition of some degree of facility in their application, else the beneficial effects of such exercises will be seriously impaired. There is always more or less danger that engineering clinics, so to call the inspection of works in progress or operation under the supervision of instructors, may degenerate into mere junketing expeditions. They may be made of distinct value, if the student really performs the work of an engineer, but not otherwise, and in order to accomplish that end he must have at least a material amount of engineering preparation. There can be no doubt, I think, of the benefit to be derived from making reports on works inspected independently by the student, beginning at as early a point in his course of study as will enable him to inspect and report upon engineering works or operations with intelligence, and continuing them at reasonable intervals until graduation. He will thus be encouraged to cultivate habits of close observation as well as the power to form conclusions, which will be of great value to him in his subsequent career.

In discussing these matters of laboratory and field work, I have not touched such topics as the study of chemistry, physics, geology, mineralogy, metallurgy, and assaying, although they should most certainly be included in the appropriate courses of engineering training. There can be no question, I think, about the efficiency of the approved methods of instruction in those subjects pursued in both the universities and advanced technical schools of the present day. The rational, experimental and field studies are so distributed and executed as to leave little or nothing more to be desired, or to be gained by discussion. It may only be observed in passing that those subjects serve very important ends in the ideal engineering education, and that they must be found occupying essential places in it.

The completion of designs and estimates and the consideration of the specifications which should govern them form a most important division of advanced instruction in engineering, which should invariably follow the rational study of the abstract principles involved. No design of any structure, machine or process can be developed on the ideal lines of pure theory, but the necessary adjustment of theoretical results to the complex conditions under which the object of the design is to perform its duty can best be made, and, indeed, can only be rationally made, through an accurate knowledge of the main principles involved. It is indispensable, therefore, that the closest possible acquaintance with those principles should be cultivated prior to that use of them which the engineer must make in the complete design of his works. These designs should be elaborated, as far as possible, with the same careful regard to detail as would be required in the actual execution of the work. The complete estimates of the various classes of material can then be made by precisely the same methods employed in engineering offices, and on those estimates of quantities should be based the estimates of cost. There is reached at this point a portion of educational work which is most difficult to manage in a satisfactory manner. Indeed, it is probable that a perfectly satisfactory result cannot be attained, but it is at least possible to so present to the student the elements of the process of estimating costs that his earliest practical experience will give him complete control of the subject. He should be made to understand that there are economic as well as mechanical principles, and that a smaller quantity of material with a larger amount of labor put upon it may considerably exceed in cost a larger quantity of material on which less labor has been expended. The reduction of shop costs through extension of facilities for handling material and the improvement of processes can be impressed upon his mind in such a way as to prompt him to pursue intelligently in his subsequent practice every effort to secure further advantages in the same direction. Such a presentation of the elements of cost of work, including cost of material, labor, handling, freight, erection, plant, tool rent, office cost, and other similar charges which it is perfectly feasible to put before him in a clear and forcible manner, will give a quality to his realization of the practical nature of engineering work which it is impossible for him to secure in any other way. It is quite within the possibilities of a course of study in engineering to convey to the student healthy and well-balanced ideas as to the influences which will affect the cost of his work, and as to the elements on which the complete cost is to be based, and no school of engineering should be considered as satisfactorily discharging its responsibilities unless it accomplishes that end.

The efficient organization of engineering offices, and that of forces and plants for the execution of specific engineering works, as well as the administration of large interests involving engineering operations, such as railways and public works, are all matters which should, if possible, be presented to the student, but in ways that are appropriate to their various characters and consistent with the amount of time and effort which must be bestowed on those other subjects which are fundamentally essential to the course of study. While it is desirable that the student should be brought in touch with these matters, so that he may know that they exist, and, at least approximately, what they are, I speak thus guardedly in reference to them, because it is not absolutely essential. He can, at best, but derive general impressions at long range, which will have to be materially corrected and developed in their full detail in his practical career; and it is neither necessary nor wise that any considerable portion of his time should be devoted to these administrative features of his later practice, which do not directly affect his immediate professional duties. These observations are not intended to be applicable to post-graduate studies in engineering, which constitute a field of work for the student in which an extended study of organization and administration can most profitably be made.

The method of instruction to be pursued in the school which affords the ideal education in engineering must be of such a character as to yield the best results with the least amount of unproductive labor to the student, and at the same time train him in the ways of vigorous and independent thought. Dry and lifeless text-book recitation work yields by itself little enough that is desirable, while the pure lecture method is equally unsatisfactory. The one is uninteresting routine and utterly ill adapted to the development of mental fertility and strength, while the other involves a mass of misdirected labor on the part of the lecturer, which, without supplementary exercises, leaves the student to shift for himself, without producing much of any result. The main purpose is to convey instruction, and it should be done in such a way as to induce the student to do his own thinking. No instructor can justify himself in merely puzzling the student with grotesque problems or in harassing him with abnormal difficulties, but, on the other hand, the student should be made constantly to feel himself a working part of the system, and that he cannot without serious loss to himself take a mere passive part. Unsupplemented lecturing on engineering subjects will not do this, although at least a very considerable amount of lecture work must be done. The fundamental groundwork of principles with the attendant analytical work and the usual or common applications can most advantageously be put into the hands of the student either in the shape of a reference or text book, or prepared notes, so that the ground to be covered by the lecturer may be carefully worked over by him prior to the lecture hour. The lecturer then need elaborate only the obscure or difficult portions of the subject matter and the application to living engineering questions. In this manner the student will be induced by reasonable and natural methods to acquire a degree of self-reliance and strength in approaching new problems that will be of inestimable value to him in his engineering practice. This should be the prelude to a close questioning on the entire ground covered by the lecture and the text. There should also be ample opportunity for explanations that may be desired by the students. In fact, a considerable portion of the lectures should be largely of the nature of conferences, so that independence of thought and a keen interest in the subject may be cultivated. A generous amount of work on problems resembling as closely as possible those arising in practice, together with full demonstrations of principles, should be constantly interspersed with the other work of the course. In these problems and demonstrations, the student should be required to defend his demonstrations against criticism. He should be trained to state and defend his views and demonstrations in a concise, clear, and forcible manner, and the attainment of that important end will require all the exercises of this character that any curriculum can afford. To my mind this matter of the best method of instruction is beset with many serious difficulties, some of which can only or best be solved in view of the personal qualifications of the instructor. It is a question that has, at least, given me years of most serious thought, both in the lecture room and in active practice, and both these phases of experience have led me by slow stages to believe that its best solution will be found consistent with the general principles I have just stated; but I also believe that in the application of these principles the largest liberty for the competent instructor in individual choice and action is most essential.

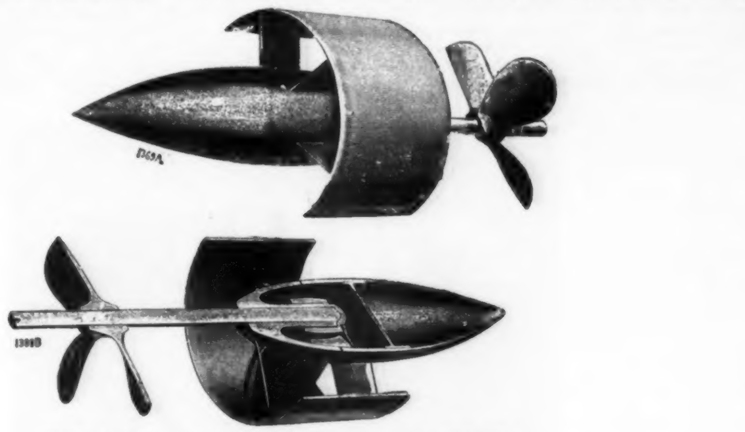
Such I deem to be the essential features and main characteristics of the course of study which will enable those who pursue it to acquire the ideal engineering education. There are then to be grouped along these main lines such a selection and number of subjects as each special field of engineering activity may require, so that each course of study may be completed in all its details. It may be, and probably will be, objected that this "ideal" is too ideal. I am confident that the objection is groundless; the ideal is already too nearly accomplished. Again, aside from such considerations, it is well to remember that that which is not the object of effort is never attained.

SCREW TURBINE PROPELLER.

We give illustrations of an improved screw turbine propeller which has recently been introduced by Mr. John Isaac Thornycroft and Mr. Sydney Walker Barnaby.

The propeller comprises a cylinder containing within it a body or boss of such a shape that the channel is gradually contracted from the forward to the after end. Within the forward part of the cylinder there are revolving screw blades attached to the forward part of the boss. The forward part of the boss is separate from the after part. It will, of course, be understood that the after part is that which ends in a point and projects beyond the cylinder. The ordinary four-bladed propeller (it appears more as a three-bladed propeller in the illustration, being in section) is forward of the screw turbine. The pitch of the forward edge of the screw blades, multiplied by the number of revolutions, is approximately equal to the velocity of the feed or speed of the screw through the water. The pitch increases uniformly along the length of the blade, thus imparting a uniform acceleration to the water. Aft of the revolving blades are placed numerous fixed blades of contrary curvature. The area of the channel through the propeller is so propor-

tioned as to suit the acceleration of the water caused by the blades. In this way there is secured at the forward end a large opening which will admit a certain quantity of water at the velocity of feed, while at the after end the area is restricted to that necessary to allow of the exit of the water at the speed of discharge. The long tapering body forming a prolongation of the boss outside the cylinder is for the purpose of allowing the stream of water to unite gradually without the formation of eddies. As the long pitch of the screw blades causes considerable rotation of the water, the curved guides are so formed as to direct the water into a straight line aft, and the rotary motion is thus utilized without loss. The efficiency of the screw turbine has been found by experiment to be at least equal to that of the ordinary screw, and a given thrust can be obtained with a much less diameter. It is, therefore, a propeller more especially suitable for light-draught vessels. The water is not accelerated at all before it reaches the propeller; in other words, there is no sucking action like that produced by an ordinary screw, and for this reason there should be less augmentation of hull resistance than with other forms of propeller, and were it not for the large surface exposed to friction, it should have a much higher efficiency than the common screw. It can be used with success where shallow draught is required, and might be applied with advantage in sea-going vessels, which are often in light trim, and do not then properly immerse their propellers, thus leading to a large waste of power. The propeller, so far as described, has the objection referred to of not being suitable for going astern. The reason of this will be apparent. The water then enters the annular space at the after end, and issues at the forward end as a revolving ring of water. Moreover, as the channel increases in area toward the forward end, the water which comes in from aft is unable to fill it, so that the middle portion of the cylinder is occupied by dead water, and some loss is probably occasioned by eddying here. In order to overcome these difficulties, supplementary blades are attached to the shaft at a little distance from the screw turbine proper, their function being to propel when going astern. In order that they should not interfere with the action of the screw turbine when going ahead, the pitch of these blades is so arranged that they simply slice their way through the water without either rotating it or driving it against the screw turbine in rear of them. This effect is obtained by making the pitch multiplied by the revolutions equal to the speed of advance. When the direction of motion is reversed to the going astern direction, these blades receive water not only through the turbine, but also from outside it. As the speed of the vessel, for a given number of revolutions, is always less when going astern than when going ahead, the blades throw a stream of water forward, and thus propel the vessel astern. If the slip of a screw were constant at all speeds, the sternway screw would be inoperative at all speeds ahead, and this is so nearly the case that it is anticipated that, if the pitch be adapted to the speed at which the slip is least, the sternway screw will not retard the vessel appreciably at any speed. In the case of a vessel used for towing varying loads, when the slip will vary as the load, the sternway screw will at times do part of the work of propelling.—*Engineering.*



IMPROVED SCREW TURBINE PROPELLER.

GULLY AND ROAD CLEANSING APPLIANCES.

SUGGESTIONS as to the possibility of a cholera plague are made from time to time in the daily press, and precautions are being taken in seaport towns with a view to promptly dealing with any cases that may occur. It is generally conceded that the greatest source of danger lies in the insanitary condition of many of the Continental towns, and we may congratulate ourselves on the comparative sanitary perfection of our large towns.

We have recently inspected an improved appliance for securing greater efficiency in the cleansing of streets, which has been adopted at Southampton. This arrangement is the invention of Mr. W. B. G. Bennett, the Southampton borough surveyor, and consists in a more expeditious and perfect method of emptying the street gullies of the road sweepings and other offensive matter left therein. The ordinary method consists in removing this offensive material by means of what is known as a gully tool—a ladle attached to the end of a long rod. This operation is often imperfectly done, and is attended with considerable discomfort to passers-by. It is certainly an inefficient method, and the conclusion arrived at by Mr. Bennett was that to thoroughly cleanse a road gully it must be constructed so as to permit of the deposited matter being speedily, entirely, and constantly removed and discharged directly into a cart or other conveyance. The "Hydraulic Self-cleansing Gully" (Fig. 1) is intended for use in places where water can be obtained at sufficient pressure from the town mains, and is arranged to be self-emptying as well as self-cleansing. The *modus operandi* is as follows: When the mud cart arrives at the point where the gully is fixed, the attendant turns back the grating and opens the water tap—a three-way cock placed in an ordinary covered box in the footpath—which admits water to a plunger below, when the mud container rises automatically (as shown in Fig. 3) and tips its contents into the cart.

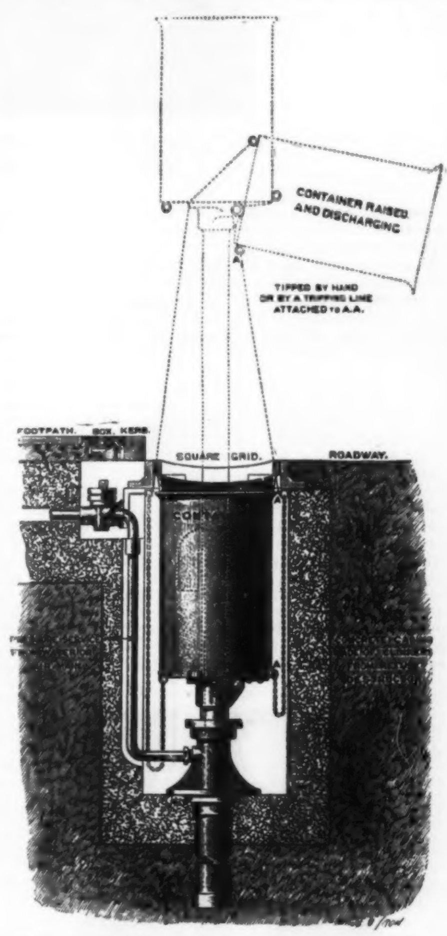


FIG. 1.—HYDRAULIC GULLY CLEANER.

Upon the operation being completed the cock is reversed, and the dirt container resumes its normal position, the exhaust water being utilized a second time for cleansing the gully pit. A provision is also made to flush out the container with clean water. One of these gullies has been in operation at Southampton by compressed air, where three miles of air main, at a pressure of 50 lb. per square inch, are laid down in the street in connection with the "Shone" hydro-pneumatic sewage system, the waste heat from the refuse destructor being utilized for compressing the air.

A second appliance (Fig. 2) has been devised for use where air or water pressure is not available. This gully is constructed of cast iron in one piece with trap combined, is easy of access, and is provided with an outlet for connecting it to an adjacent drain. These gullies are also equally available for the cleansing of roads, the slurry being easily swept into them. In many cases it would seem advisable, as, for instance, at a circus or junction of several streets, to simply construct small chambers covered with ordinary gratings and connect by pipes, unobstructed by traps, to a common center, where one of these appliances could be fixed, the overflow passing direct to the main rainfall sewer.

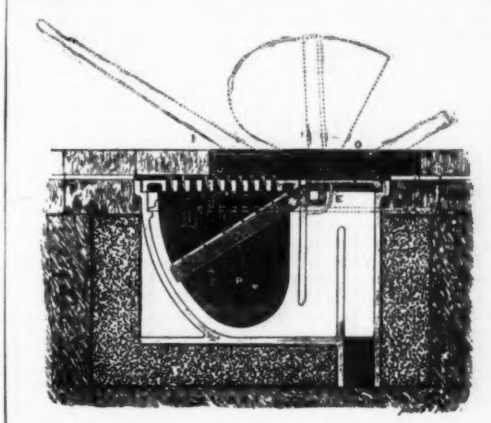


FIG. 2.—GULLY CLEANER.

Naturally, the initial cost of this system is greater than that of the ordinary means at present employed, but the advantages accruing therefrom are patent, and we have no doubt that it will come into very general use.—*Industries.*

FIG. 3.—EMPTYING A GULLY.

THE DISTRIBUTION OF REFRIGERATION IN CITIES FROM CENTRAL STATIONS.

THE principal hotels and restaurants and downtown butcher shops in St. Louis and Denver are using this system in their storage boxes. But the applications of the system do not end here. In many hotels, cafes, and saloons ice is required for water pitchers and to crack up for mixing beverages. In such cases a miniature brine tank is provided, through which the expansion coils connecting with the pipe line are run. Moulds of suitable size are placed in the brine, and the operation of ice making is carried on just as at the large ice factory.

Where small amounts of ice are needed for cracking up, a small insulated reservoir is provided and the expansion pipes are placed close to the sides. Water is then poured into a reservoir and ice forms on the expansion coils and extends toward the center of the reservoir until a solid mass is frozen. This is chipped as desired, and new water added from time to time.

Another important branch of the business is supplying cold water for large stores, factories, and offices. The installation for this service consists of a watertight insulated tank, having at the bottom a coil, through which the hydrant water is passed on its way to the taps. About a foot of water is poured in on the top of this coil, and just underneath the surface of this water the expansion pipes are placed. A sheet of ice five or six inches thick is formed by the action of the expansion coil, thus keeping the water coils constantly surrounded with ice water of low temperature.

The city water so cooled may then be carried by insulated piping to taps in any portion of the building. Some large installations of this kind are in successful operation. The cooling of soda water fountains is effected in the same way. The manufacture of ice cream is also more easily accomplished by the aid of this system. Other branches of business are also supplied, as the manufacture of perfumes and chocolate confections.

Among the luxuries furnished by this system may be mentioned the cooling of living rooms, which, in such a climate as that of St. Louis, proves a great luxury. The refrigerating company there started in with contracts to reduce the temperature of cafes and dining rooms twenty degrees below the outside temperature. No difficulty was found in cheaply reducing the temperature even to a lower point than this, but sanitary considerations and the comfort of the frequenters of such places determined that a difference of from ten to fifteen degrees between the inside and the outside temperatures was the most satisfactory.

It is interesting to note that the same piping used

for the ammonia cooling service in the summer is used for steam heating purposes in the winter. It happens that in neither Denver nor St. Louis do the pipe lines reach any of the hospitals, though the benefit of their use in such institutions is apparent.

Figures are given to show that this service is less costly than the shipping of ice, and that it can be operated profitably in towns having 20,000 or more inhabitants.—*Engineering Magazine.*

PHOTOGRAPHY OF THE HUMAN EYE.

THIS very interesting question has already evoked numerous researches, but the results obtained still leave much to be desired. Besides the proper color of the parts to be reproduced, which is far from being actinic, the principal obstacles are due to the difficulty of properly illuminating the eye and keeping it sufficiently immovable, and to the reflections from the cornea, which may entirely vitiate the results obtained. Hence a certain number of processes and methods which it is interesting to summarize before describing a new arrangement that appears to us much superior to those that have already been pointed out, and that has just been realized in the laboratory of Mr. Charpentier, professor at the Faculty of Nancy, by Mr. T. Guilloz, chief of the laboratory work in physics of the said faculty.

It is Noyes, of New York, who, in 1862, seems to have made the first tentatives, but he encountered a difficulty in the way of a want of sufficient sensitiveness of his plates. Sinclair, of Toronto, was at the same time pursuing analogous studies, but he gave them up for the same reason.

In 1864, Rosenburgh proposed an apparatus formed of two tubes crossing each other at right angles and provided at their intersection with a plate of glass placed at an angle of 45 deg. with respect to the axis of the two tubes. The solar light, condensed by a lens, was reflected upon this plate of glass and illuminated the eye placed at the extremity of the other tube. At the opposite side a lens of short focus placed near the plate of glass furnished an inverted image, which was taken up by a second lens performing the functions of an objective, and was projected upon a plate of ground glass fixed at the extremity of the tube. Under such circumstances an upright image of the back of the eye was obtained. In this arrangement the reflections of the cornea were excessive, and Mr. Rosenburgh could not eliminate them sufficiently.

Liebrecht proposed to illuminate the eye by means of a concave mirror of very short focal distance, the center of the mirror having a wide aperture. The objective was placed immediately behind this aperture and thus received the return rays. The image at the focus of the camera was inverted.

In 1884 Mr. Dor, of Lyons, presented to the Congress of Copenhagen photographs taken of Perrin's artificial eye and of the eye of a chloroformed cat and of the rabbit. The arrangement as to principle was quite analogous to that of Rosenburgh, but the illumination was obtained in a very practical manner by means of Trouve's photophorus.

The electric light was employed by Jackmann and Wersbert, who obtained photographs of the human eye with Jull's ophthalmoscope. The time of exposure was two minutes and a half, which was lengthy, and the reflections of the cornea were not avoided.

In 1888 Cohn proposed a special camera for the photography of the back of the eye, and the object of which was to suppress the time necessarily lost between the focusing and the exposure, and to take the photograph at the most favorable moment. Two identical rhombohedrons placed in the passage of the luminous rays gave two images of the object observed. One was received upon a ground glass and permitted of effecting the focusing; the second was received upon the sensitized plate when the latter was uncovered by means of a special shutter. This arrangement was an application of the principle realized in Giraud-Teulon's binocular ophthalmoscope. This scientist, in the latter years of his life, had, moreover, devised a prism apparatus especially designed for photographic studies.

The inconvenience of all these arrangements is that there is utilized for photography only half of the light reflected by the back of the eye, without counting the losses by absorption in the prisms or rhombohedrons, and that are far from being insignificant.

Hope, of St. Petersburg, and Galezowski, in France, occupied themselves with the question, but always insisting upon the difficulties experienced in suppressing the corneal reflections.

In 1889, some researches were made at the laboratory of medical physics of the Faculty of Nancy by Mr. Bagneris. He used for the lighting of the eye an equilateral prism placed near the latter, but in such a way as to encroach upon only a part of the pupil, the other remaining free for the passage of the return rays.

A lens of 6 dioptrics placed at 6 centimeters from the surface of the prism sent a convergent pencil upon the corresponding surface of the latter. The rays refracted by the first surface, reflected by the second, made their exit at right angles with the third in converging toward the camera, and illuminated the retina. The objective, placed at 45 millimeters from the eye, photographed the upright image. Bagneris obtained with the Perrin artificial eye 5-centimeter images in 15 seconds, the illuminating source being a simple gas lamp.

In 1891, at the congress of Heidelberg, Mr. E. Fick, of Zurich, pointed out the reasons for which it seemed preferable to him to photograph the upright rather than the inverted image, and he proposed to place a contact glass in front of the eye in order to prevent corneal reflections.

The completest result was obtained by Gerloff, at Göttingen, and presented by Dubois-Reymond at the session of October 17, 1891, of the Physiological Society of Berlin. The process employed, very different from the preceding, consists in fixing before the eye, previously atropinized and cocained, a cup whose anterior part is formed of a plate of glass with parallel surfaces. This cup is filled with a physiological solution of chloride of sodium. With this arrangement, it appears that the influence of the cornea is eliminated.

As a source of light, Gerloff employed a zircon or magnesium lamp, or the magnesium flash light. The reflector was formed of a laryngoscopic mirror, immediately behind the aperture of which the objective was placed. The aperture of the mirror, which measured one centimeter, performed the role of a diaphragm.

Although the results obtained by Gerloff were much superior to those obtained by his predecessors, the manipulation was delicate, the dimensions of the photographic image were quite feeble, and special precautions were required to eliminate the reflections produced by the cup. Upon the whole, as well says Mr. Guilloz, whose new method we are going to describe, it is necessary in the photography of the back of the eye to realize the following conditions: (1) To obtain the greatest portion possible of the back of the eye; (2) not to require of the subject an absolutely correct direction of the line of sight, for this condition, apparently so simple, is more difficult to realize than might be thought during the ophthalmoscopic examination, and especially during the photographic operation; (3) not to require any steadying apparatus either for the head or the eye; (4) to suppress the blepharostat and the water cup, the application of which is always difficult; (5) to obtain the photograph in so short a space of time as not to require immobility of the subject; (6) the light employed must cause no visual disorder, nor even modify the acuteness during an appreciable time; (7) the arrangement adopted should permit of operating at the precise moment at which the image forms in the best conditions.

FIG. 1.—GENERAL VIEW OF GUILLOZ'S APPARATUS FOR PHOTOGRAPHING THE EYE.

In order to satisfy the first conditions, Mr. Guilloz prefers to photograph the inverted image, and he obtains it very simply by illuminating the eye with a source of light placed at 30 or 50 centimeters and in making use of a simple magnifying glass. The observer, placed immediately behind the source and shielded from it by an opaque screen, forms the inverted image with the magnifying glass, and examines it monocularly, his visual line being tangent to the edge of the screen. If, then, the eye of the observer be replaced by the photographic objective, there will be obtained at the focus of the latter an upright image of the back of the eye.

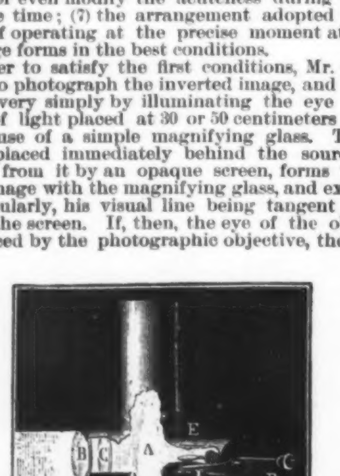


FIG. 2.—DETAILS OF THE LAMP.

General Arrangement.—Fig. 1 gives a general view of the arrangement devised by Mr. Guilloz. The subject is placed in front of a support that carries the magnifying glass. His eye is illuminated by means of a special lamp that we shall describe, and the image is received by the photographic apparatus modified in a very ingenious manner.

The magnifying glass employed is a lens of from 15 to 20 dioptries set into an oculistic box. It is mounted in such a way as to be able to take all positions. The lamp (Fig. 2) is an ordinary gas one whose glass is replaced by a sheet-iron chimney provided with two lateral tubulures at the level of the flame. The first, which is directed toward the subject, receives a lens, B, whose focus occupies the position of the flame, A. There will thus be obtained a parallel pencil that will permit of properly illuminating the eye in order to examine it, and then to effect the focusing. In front of the lens there is placed a disk of plane glass, C, of the same diameter as the latter. The object of this plate of glass is to protect the lens against the products of combustion of the magnesium that will give at the desired moment the illumination necessary to obtain the photographic image. In fact, the magnesium flash light has the advantage of giving a very considerable amount of light in a very short time. It therefore does not necessitate an absolute fixedness of the eye, and consequently suppresses one of the principal difficulties of the problem.

The second tubulure contains a special arrangement that Mr. Guilloz calls a "magnesium pistol," and the object of which is to project, at the proper moment, the illuminating mixture into the flame. A square rod, D, runs through the bottom of the tubulure. Its anterior extremity possesses a small cavity to contain the illuminating mixture. A spiral spring surrounds the rod concentrically, and when the latter is carried back by pulling the extremity that passes beyond the tubulure, the spring will be compressed. At the end of the travel the mechanism will be automatically freed, and the pistol will be cocked.

At this moment the small cavity that is to receive the illuminating mixture will be exactly underneath a slide trap, E, that will permit of introducing the latter. When the pistol is set free, the rod will be abruptly thrown forward, and, reaching the end of its travel, the illuminating mixture, thanks to the impulsion acquired, will be projected into the flame, where it will take fire and produce the magnesium flash. The freeing of the pistol is obtained by means of a pneumatic arrangement, F, which is controlled by a rubber bulb that the operator compresses automatically at the precise moment at which he uncovers the photographic plate.

The illuminating mixture is formed of two parts of magnesium in powder and one part of chlorate of potasa. The quantity necessary does not exceed 0·2 or 0·3 gramme in each operation. The duration of the combustion is a fraction of a second, which is a most valuable advantage, for the eye has no time to budge. After each flash it is necessary to clean the plane glass which is in front of the lens forming a condenser, in order to free it from the magnesia that covers it.

The photographic apparatus is modified in the following manner: At the posterior part is situated a box into which is set a mirror at an angle of 45 degrees. This mirror is movable upon its upper edge, and may be raised at a given moment against the upper part of the box. It will then uncover the plate that is situated at the usual place in this box. In order to effect the centering of the image and the focusing of it, the back box is provided at its upper part with a horizontal ground glass upon which the image is sent by the mirror when it is at 45 degrees.

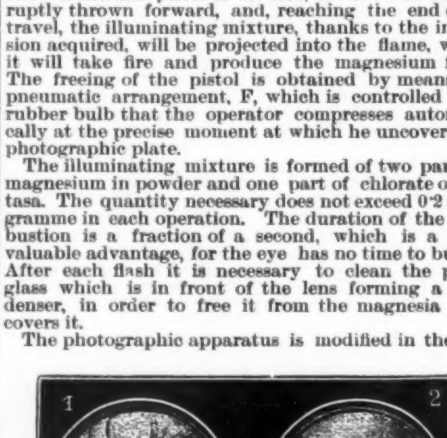


FIG. 3.—PHOTOGRAPHS OF THE EYE.
1. Normal eye. 2. Diseased eye.

In this case, as the mirror occupies exactly the bisector of the angle formed by the ground glass and the sensitized plate, when the image is sharp on the ground glass it will be equally so upon the sensitized plate.

The mirror is controlled by two handles fixed to

the extremities of its axis of rotation, and, after it has reached the end of its travel, it is one of these handles that effects the freeing of the magnesium pistol.

The impression of the plate occurs, and the mirror is then allowed to fall back to protect it. The light furnished by the gas lamp is not very intense, but nevertheless it would be impossible to leave the plate uncovered with impunity; so as soon as the flash has taken place it is put under cover. It is also for this reason that the focusing is quite delicate, and Mr. Guilloz proposes to employ a glass finely ground or even oiled, or a glass provided with a few lines drawn with a diamond at its lower part. It is a process, moreover, that is often employed in micrography. In this the image is examined with a magnifying glass that has been regulated for giving the ruled lines with the greatest distinctness, and, when it is in the same plane as the lines, one is assured of the maximum of fineness.

Rapid plates and energetic developers must naturally be used. The development is effected exactly in the same way as with all instantaneous photographs.

Method of Operating.—One should always operate after obtaining the dilatation of the pupil, but as there is no need of this effect lasting long, it is preferable to employ substances whose action is rapid and not very durable. Mr. Guilloz has fixed upon a collyrium composed of a mixture of 1-30 per cent. of hydrochlorate of cocaine and 1 per cent. of hydrochlorate of hematropine. The action of this is very rapid, but quite fugitive. In this way the eye is not unreasonably discommoded.

The subject rests upon the head support of the Javal ophthalmometer, as if it were a question of determining astigmatism of the cornea. The eye is illuminated and the lens is placed in front of the latter in such a way that the focus shall occupy nearly the pupillary plane. Then the lamp is shifted, and the magnifying glass, too, if necessary, until the observer's eye, placed behind the luminous source, sees the reversed image. The subject is made to direct his sight exactly as if an ophthalmoscopic examination were to be made. A proper position of the eye having been obtained, the photographic apparatus is so arranged that the objective shall occupy the place that the eye of the observer occupied during the regulation. The focusing on the upper ground glass is effected, and, when the image is satisfactory, the mirror is raised, the magnesium flash is produced and the mirror is then allowed to fall.

These general arrangements assure that rapidity of execution which is indispensable in the case. An upright image of the back of the eye is finally obtained.

We give reproductions of two of Mr. Guilloz's photographs, one representing a normal eye (Fig. 3, No. 1), and the other a pathological eye (Fig. 3, No. 2). These very readable results evidently constitute a very serious progress over anything of the kind that has been done up to the present. Nevertheless, it will be found that the reflections are not eliminated completely. In addition to the corneal reflections, there are others produced that are due to the reflection of the illuminating pencil both upon the lens and the cornea itself.

These reflections are shown by white blotches of circular form, but it is not possible to confound them with a pathological blotch. It is possible, however, through an artifice that consists in slightly displacing the magnifying glass, to throw them toward the periphery of the image, so that the center of the latter shall be completely free from them. Now this is the part that is the only interesting one.

The displacement of the magnifying glass equally favors the corneal reflections. Mr. Guilloz, however, has submitted to us only his first results, and he seems to be convinced that by the method that he has pointed out he will be able, through proper arrangements, to eliminate the reflections radically.

There remains a final question, and that is of the action of the magnesium flash upon the eye. It may be asked, in fact, whether it is not dangerous to employ so bright a source of light, and whether the normal eye and the eye already diseased can support it with impunity.

From a series of experiments to which Mr. Guilloz has submitted himself, he finds that the eye can support the flash without danger in the conditions of the experiment. No trouble was found and the visual acuteness was not diminished. It would appear, even from certain experiments made upon myopes, that the latter are less discommoded by the light of the flash as patients than as spectators. Mr. Guilloz explains this fact by remarking that in the first case the illumination is distributed over the retina in a diffuse manner, while in the second the retinal images of the illuminated objects form sharply upon the retina. Consequently, in the second case, the illumination per unit of surface may possibly be greater than in the first. However this may be, the conclusion of those researches is that the photography of the back of the eye may be effected without danger to the subject, and this, we think, will permit the method to enter current practice.—*La Nature.*

HENRY'S PHOTOPTOMETER.

WHERE begin what we call darkness, blackness, absolute night, the region in which luminous vibrations are extinguished?

Where finishes the light that our human eyes perceive—those poor eyes, windows of the soul, as the poet says, so perfect in their physical construction, and yet so delicate that one is astonished to see them last until the end of a long human existence?

Such, in sum, are the two questions that Mr. Charles Henry, a distinguished scientist and librarian of the University at the Sorbonne, has treated with the clearness and precision of scientific experimentation; and he has presented a very interesting communication on the subject to the Academy of Sciences.

It is to the subject of the extreme *debut* of light, or rather of luminous vibration, that Mr. Henry has devoted himself.

It is relatively easy, by veiling their brilliancy through diaphragms, smoked or colored glass and scientific and attenuated repercussions, to regard great sources of light and compare them with each other.

Their very shadow, as happens with all glories, through the interposition of a simple screen, permits of measuring their relative luster. We can thus estimate and compare incandescent gas, the brilliant electric illuminator and the source of all terrestrial energy that is called the sun.

But if we rise in the opposite direction toward the density of darkness, the problem itself also becomes dark, for the human eye announces to us already that it is dark while it is as yet only dim in the mechanical scale of vibrations.

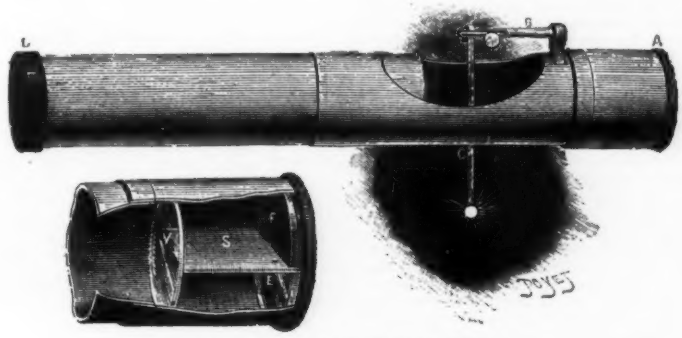
Mr. Henry proposed to himself to determine this scientific basis, which is indisputably useful, since upon its truth, placed at the lower extremity of the scale, depends the precision of all that follows. With this object in view, he has devised a photoptometer—a delicate apparatus that has greatly interested our savants of the institute. This little apparatus accurately measures the smallest quantity of light that the eye can distinguish—light corresponding to a few thousand millionths of that given by the candle that is generally taken as a standard or as a photometric unit.

It was by making use of a phosphorescent substance that our physicist attained his object. The phosphorescent bodies, that is to say, in general, the sulphides, are extremely sensitive to light. Modern science has succeeded in preparing them in the laboratory, but nature utilized them long before it. In fact, it is to in numerable minute animals that the waves of the sea owe their phosphorescence.

Recent researches have shown that the marine animals inhabiting the great unexplored depths are phosphorescent and of varied hues. They illuminate their route and give themselves up to their struggle for existence in the abysses, thanks to a property that consists in emitting light as a consequence of the feeble luminous vibration that penetrates the depths.

One has so well succeeded in practically utilizing this curious property of phosphorescence that it has been possible to employ it for painting reefs, as well as lighthouses, which thus become luminous and visible at great distances in darkness. It is made use of also for painting certain maneuvering parts of lifeboats, which have to accomplish their humanitarian work in darkness.

We shall not follow Mr. Henry in his theoretical deductions, which are based practically upon the following fact: The phosphorescent sulphide of zinc that he has succeeded in preparing industrially possesses inalterability. The law of the loss of its light with time being well determined, it is, therefore, able to serve



HENRY'S PHOTOPTOMETER.

for the measurement of a very feeble light. It is upon this principle that the Central Society of Chemical Products has constructed the photoptometer-photometer, which will dissipate many material and scientific darknesses.

This apparatus consists of three tubes blackened internally and united. The one that is applied to the eye is provided with a convergent lens of great focal distance. This arrangement suppresses from the field of distinct vision the sides of the tube, which slides into another provided with two elliptical apertures above and below. A magnesium ribbon, 3 millimeters in width and 15 in length, suspended from an arm, is designed to burn in this space, which is insulated from the interior of the apparatus by two protecting glasses. These dimensions of the ribbon suffice to give the sulphide the maximum illumination. To the central tube are screwed: (1) internally, a ring capable of holding a number of ground glasses, variable at will, in view of photometric applications; (2) externally, an anterior tube terminating in two semicircular screens separated by a partition at right angles. One of the screens is composed of ground glass of a greenish yellow color identical with phosphorescence, and for which may be substituted another screen less absorbent. The other is covered with phosphorescent sulphide of zinc. The manipulation is easy. If it is a question of measuring the light of an external source, the back tube is separated from the front one. The magnesium ribbon is lighted, and the time at the moment of extinction is noted. The back tube is then placed against the front one, and the time is noted at the end of which there is an equal brightness between the phosphorescent screen and the translucent one. The ratio immediately gives the illumination of the source.

Mr. Henry has thus measured the illumination of all sorts of false darknesses. The full moon in Sologne gave 0·272122 bougies meter; 27 one-hundredths of a bougie meter when one is the moon and one reflects the sun! On the 12th of last August, at 11 o'clock at night, there was 0·235504 of a bougie meter of light in the Boulevard Saint Jacques, at Paris, less than in Sologne! And Paris is called the City of Light!

Our physicist likewise measured, on the 22d of August, that "pale light that falls from the stars," which he calls their diffuse light. What would the great Corneille have said on learning that this pale light is measured by 0·00057047254?

One very interesting thing is that Mr. Henry has proposed to himself to measure the sensitiveness of the eye by the inverse of the minimum perceptible, after a stay of known duration in darkness, or after an exposure of the eye to a light of definite intensity. There will result from this, on the one hand, a whole series of methods of investigation for recognizing whether people are myopes, blind, or in the way of becoming so. It will be possible, too, to ascertain within what limit the present great luminous sources cause the eye to work. There is a marked tendency, thanks to improvements in recent processes, to inundate the public with electric light. We are beginning, even, to become so accustomed to it at Paris, at least, that the streets and boulevards lighted with gas have the effect of cut-throat places and wells of darkness upon us; while, ten years ago, their brilliant and joyous light was spoken of. That is very well, but will not our orgies of light condemn us much more than our fathers to more or less frequent and premature blindness? There is here a great black point. Mr. Henry will tell us this, and will perhaps permit us to avoid the danger, either by inducing us to go to bed early or by wearing blue spectacles on grand occasions.

But it is not to this sole possible consequence that these useful works lead us. To accurately measure feeble luminous vibrations is perhaps to render it possible to photograph at great distances—that is to say, to transmit the speech and image of an individual by telephone. It is to permit of assuring one's self of the real death of a person through ascertaining that his eye is decidedly dark and that it will never see again. It is the possibility of estimating the depth of abysses through the little light that penetrates them. Finally, it is, as we said in the first place, the possibility of accurately measuring all illuminations in starting from a fixed zero instead of proceeding by uncertain comparisons.—*L'Illustration.*

THE PERMEABILITY OF GLASS.

IN Professor Roberts-Austen's second report to the Alloys Research Committee of the Institution of Mechanical Engineers, he describes certain interesting experiments made by Messrs. Warburg and Tegetmeier, demonstrating the permeability of glass. It may not be generally known that the Hon. Robert Boyle published an account in 1673 of experiments made by him with a somewhat similar object. Although the conclusions which he deduced from these experiments are erroneous, yet it is interesting scientifically, as well as historically, to watch the process by which these conclusions were arrived at; and also to observe how, when once a preconceived notion had taken possession of Boyle's mind, every successive experiment led him farther from the truth.

He seems to have set out with the intention of investigating the nature of light, thinking it "worth the inquiry whether a thing so vastly diffused as light is were something corporeal or not;" but sunbeams being scarce at that time, "because the weather proved so extraordinary dark and unseasonable that it was wondered at," he determined to defer the experiments with solar light, and try what could be obtained from flame.

The account of the experiments is divided into three sections. The first is headed, "New Experiments to make Fire and Flame Ponderable;" the second, "Additional Experiments about Arresting and Weighing of Igneous Corpuscles;" and the third, "A Discovery of the Perviousness of Glass to the Ponderable Parts of Flame." The results are summarized thus: "Flame itself may be as 'twere incorporated with close and solid bodies, so as to increase their bulk and weight, and also that glass was permeable to flame."

In the first set of experiments Boyle exposed small plates of silver, copper, tin and lead severally to the direct action of the flame of burning sulphur for the space of two hours. The plates were then found to have increased in weight, the copper from 2 drachms 25 grains to 4 drachms 3 grains, the silver from 25¼ grains to 1 drachm 5 grains, and an ounce of tin to 1 oz. 1 drachm. Boyle concluded that the "igneous corpuscles" had combined with the metal, and here he seems to have been not far from the truth. The following experiment might have shaken his faith in his theory, but he makes no comment on the result. A portion of powdered brick was heated in a covered crucible for two hours, but was not found to have "gain'd or lost" in the operation. An ounce of lead, heated for some time in a cupel (placed in a charcoal furnace), was found to be converted into litharge weighing 7 grains more than the lead, and an empty cupel of bone ash and charcoal, weighing 2 oz., was found to have increased in weight by 21 grains, after being heated in a muffle for two hours.

"Whether I should have been able by reduction, specifick gravity, or any other of the ways which I had in my thoughts, to make any discovery of the nature of the substance that made the increment of weight in our ignited bodies; the want as well of leisure, as accommodations requisite to go through with so difficult a task, keeps me from pretending to know."

The second set of experiments dealt with metals inclosed in glass retorts heated over a charcoal fire. Boyle found that 8 oz. of tin kept in a melted state in an open glass vial for an hour had gained in weight

18 grains. He says: "Although these tryals might well satisfye a person not very scrupulous, yet to convince even those that are so, I undertook, in spite of the difficulties of the attempt, to make the experiment in glasses hermetically seal'd to prevent all suspition of any access of weight accruing to the metal from any smoak or saline particles getting in at the mouth of the vessel."

The first retort burst, but another with a long neck sealed at the end, and containing 8 oz. of tin, was held over the fire, so as to keep the metal fused for an hour and a quarter, "as (being hinder'd by a company of strangers from being present), my laborant affirm'd." The metal remaining, and the "calx" which Boyle elsewhere describes as "an aggregate of metal and extinguished flame," were found to weigh 8 oz. 23 grains. To show that metals are not the only bodies capable of receiving increase of weight from a fire, he tried the effect of similar treatment on coral and quicklime, both of which showed an increase in weight. He quaintly argues concerning lime that, "though well-made lime be usually observ'd to be much lighter than the stones whereof 'tis made; yet this lightness does not necessarily prove that because a burnt limestone has lost much of its matter by the fire, it has, therefore, acquired no matter from the fire, but only inferrs that it has lost far more than it has got."

In the third set of experiments the substances were submitted to the heat of flames, "that I might obviate some needless scruples that may be entertain'd by suspitious wits upon this circumstance of our additional experiments. That the glasses employ'd about them were not exposed to the action of mere flame, but were held on charcoals (which to some may seem to contain but a grosser kind of fire)."

To this end he exposed a retort containing 2 oz. of tin to the flame of burning sulphur for 3½ hours, "as the laborant inform'd me (the smell of brimstone, peculiarly offensive to me, forbidding me to be present)." The increase in weight was 4½ grains, "if both the laborant and I be not mistaken, for the paper which should inform us is now missing." Boyle seems to have been just a little careless with this experiment, but his frankness is admirable.

To make sure that the increase in weight was not due to particles of the glass itself, separated "and forcibly driven into the inclos'd body by the heat," he weighed two empty retorts before and after heating. One retort seems to have gained ⅛ grain, but he says "there was no likelihood at all that so considerable increase of weight (as that observed in the other experiments) should proceed from the glass itself and not from the fire." As a mere matter of probability, one would have thought the former supposition to be the more reasonable of the two. It seems a pity that Boyle did not weigh his retorts and their contents separately and together before and after heating. If he had, the discovery of oxygen might have been made 100 years earlier than it was, but he seems, by a sort of fatality, to have continually missed the paths that might have led him to that result.

In his subsequent experiments the fuel used was spirits of wine, as affording a purer flame than that of sulphur. An ounce of tin filings was melted in a sealed retort, and exposed to the heat of a spirit lamp for two hours, at the end of which time the metal and "calx" had gained 4½ grains, "besides the dust that stuck to the sides of the retort, which we reckoned enough to make ½ grain more, so that of so fine and pure a flame as of this totally ardent spirit, enough to amount to 5 grains was arrested, and in good measure fix'd by its operation on the tin it had wrought upon. Whence can this increase of absolute weight (for I speak not of specifick gravity) observ'd by us in the metals expos'd to the mere flame be deduc'd, but from some ponderable part of that flame? And how could those parts invade those of the metal inclos'd in a glass otherwise than by passing through the pores of that glass?" Reasoning unanswerable till 1774, when Priestley's discovery of oxygen cleared away this and many another fallacy. To a person ignorant of the existence of oxygen, Boyle's reasoning would appear conclusive, but to us it will only appear strange that he was not led by his experiments to make the discovery which Priestley made 100 years later.

More than once he came very near, but each time he almost willfully shut his eyes to it. He does not seem to have had the faintest suspicion, at any time, of the possibility of the increment of weight coming from the atmosphere.

There is another line of investigation, which one regrets the philosopher did not follow up, although he mentions it in a "corollary" as follows: "Whether these igneous corpuscles do stick after the like manner to the parts of meat, drest by the help of fire, and especially roast meat, which is more immediately expos'd to the action of the fire, may be a question which I shall now leave undiscuss'd, because I think it difficult to be determin'd, though, otherwise, it seems worthy to be consider'd, in regard it may concern men's health to know whether the coction of meat be made by the fire, only as 'tis a very hot body, or whether it permanently communicates anything of its substance to the meat exposed to it."

ANCIENT RIVER BEDS OF THE FOREST HILL DIVIDE.

THE Forest Hill Divide, one of the numerous spur-like ridges of the western flank of the Sierra Nevada, is in Placer County, between the north and middle forks of the American River. The ridge line is uniformly graded and unbroken for 25 miles or more, extending from an altitude of 5,800 to 2,300 feet above sea level. Midway between these points the ridge branches, the northerly branch being the Iowa Hill Divide, and the southerly, or main branch, the Forest Hill Divide proper. An examination of the district shows that the bases and main bodies of these ridges are composed of metamorphic rocks of great age, and that there are commonly exposed on the summits large accumulations of volcanic material and extensive river deposits of a comparatively recent geological epoch. In a popular sense, however, these deposits are decidedly ancient and they have been appropriately credited to an ancient river system. A characteristic cross-section of the Forest Hill Divide is given in Fig. 1 of the accompanying engravings, which we take from an article by Ross E. Browne, M.E., in the last published report of the State mineralogist, condensing also the descriptive matter.

The River Deposit consists of well washed bowlders, pebbles, and sand, composed of the harder materials eroded from the bed rock, mostly quartz and siliceous rocks. Clay strata are of frequent occurrence, particularly in the upper portion of the deposit. Trunks of trees, commonly cedars and oaks, are found embedded in the upper layers, either petrified or somewhat lignitized. Certain layers of the gravels thus formed have become strongly cemented, owing, probably, to the percolation of siliceous and calcareous waters. The color is gray, blue, green, reddish brown, or white, according to the material, as well as the degree of oxidation of the iron in the cementing substance.

Gold occurs throughout this deposit in the form of rounded nuggets, scales and dust. The occurrence is the result of the breaking and grinding of fragments and bowlders of the gold-bearing portions of the bed rock.

By a natural process of concentration the bottom layer of each deposit of gravel has become, as a rule, the richest.

That these auriferous gravels are river deposits was but one of a number of theories advanced during the first decade of active mining operations. The theory was well established, however, by Professor Whitney, in his earlier work as State geologist, and the accumulating evidences have long since become conclusive.

The Volcanic Cap consists of massive layers of beds of light gray, reddish brown, and dark colored cements and conglomerates. It contains large bowlders and fragments of volcanic rocks, and in its bottom layers occasional trunks and branches of trees somewhat lignitized. It carries no appreciable quantities of gold and is, in fact, the barren material of the district.

Between these massive beds are layers of gravel, marking distinct periods in the flow.

The Forest Hill Divide has been for thirty-nine years an active field for mining enterprise. There has been exposed by hydraulicking many sections of the river deposit and extensive areas of the river beds; and by drift mining a number of the channels have been explored and worked continuously for a mile or more of their lengths.

Of the mining terms used it appears necessary to define a few only: "Channel" refers to the deeper portion of the continuous trough-like bed of the river; "rim" to the sides of the trough, from the line above where the bed rock begins to pitch down to the shore line of the bottom layer of gravel filling the channel; "upper lead" to an upper layer of pay gravel; "bench gravel" to a patch of an earlier deposit of gravel remaining in place after the greater portion has been washed away.

The network of channels under the volcanic cap is rather confusing. There are evidences of a number of channel systems, each representing a partial or complete displacement of the stream, a distinct cut, and a special deposit of gravel.

The series of volcanic eruptions in the high Sierras had a marked effect upon the watercourses and has enabled a ready grouping of the channel systems according to three important periods, covering the time before, during, and after the series of eruptions.

Prior to the first important flow of volcanic cement, this period is represented by a system of continuous valley-like depressions in the bed rock, from a thousand to several hundred feet in depth and several miles in width, and containing broad river beds filled with gravel to very considerable depths. The rivers, in eroding the bed rock and forming these depressions, left a succession of broad, flat benches with shallow accumulations of gravel. The channels naturally followed, to a great extent, the belts of soft slate. This slate is easily eroded, slakes readily, and is washed away in the form of a fine silt. Quartz is the only important material contained in the belts which is hard and permanent enough to resist the destructive action of the current. Owing to these facts we find in the filling of the channel, for long stretches, quartz gravel and quartz sand almost to the exclusion of other materials. The white channel of the Mountain Gate and Hidden Treasure mines is a striking example. (See Fig. 3.)

The channel is filled to a depth of 50 ft., and a width of one-third of a mile, almost exclusively with smoothly washed bowlders, pebbles, and sand of pure white quartz. On top of this, to a depth of 150 ft. or more, and an original width probably exceeding a mile, the filling is quartz sand and sandy pipe clay. The course of these belts of soft slate being south, or somewhat east of south, and not entirely continuous, and the general slope of the surface being to the southwest, the channels occasionally break across the harder belts of bed rock. The quartz gravel decreases in quantity, and there are substituted pebbles and bowlders of equally hard siliceous metamorphic rocks. There appears no conclusive evidence of the occurrence during this period of any disturbances to cause a wide diversion of the watercourse, and Mr. Browne is unable to say whether the period is represented by one large channel system only, with its tributaries, upper leads, and benches on the valley slopes, or by several such systems.

The first important volcanic eruption in the high Sierras changed the conditions. A mud composed of fine volcanic material was delivered to the river bed and washed down its course, spreading over the gravel to a considerable depth, solidifying and sealing the river deposit. The streams were diverted by the cement cap thus formed, and the first period came to a close.

Second Period, or period of the series of volcanic cement flows—the capping of the older channel deposit occurred in a succession of flows. The watercourse was several times diverted by the heaping masses of volcanic materials. During the intervals between the periods of volcanic eruption both shallow and deep narrow channels were cut, sometimes following and partly obliterating the older deposit, sometimes crossing and leaving the deeper portion of the older bed altogether. Some of these later cuts are higher than the earlier; several of them, however, passed entirely through the older deposit and 50 to 100 ft. deeper into the bed rock. (See Figs. 3 and 4.)

The "blue channel" and the "volcanic gravel channel," shown in the section, represent two such cuts. The "blue channel" contains, in its lowest depression, five to fifteen feet of bed rock gravel of a grayish blue color, and on top of this eighty feet of cement, then a layer of four or five feet of bed rock gravel; and on top of this again, cement. The "volcanic gravel channel" contains a large body of coarse gravel, composed mostly of volcanic rocks, and to a small extent only of bed rock. These two channels represent distinct systems. The volcanic gravel channel is doubtless the later of the two, possibly the latest of the deep channels of the period. The final bed of the period was filled with coarser cements and conglomerates to a great depth. Volcanic eruptions in the high Sierras ceased altogether, and thus the cause of frequent diversions of the watercourse disappeared.

Third Period, immediately following the last important flow of volcanic cement and extending to the present time: There still remains of the volcanic cap from 300 to 1,000 ft. in depth. The ancient valley was filled to depths even greater than these, and there resulted a wider and more permanent diversion of the watercourses than heretofore. The streams started new channels, probably along the marginal lines of the cap, cutting across the cap at the juncture of tributaries of early periods, and ultimately obliterating the greater part of the deposits of the first period and a large part of the deposits of the second period. These streams, undisturbed by volcanic activity, have continued to

Fig 2.

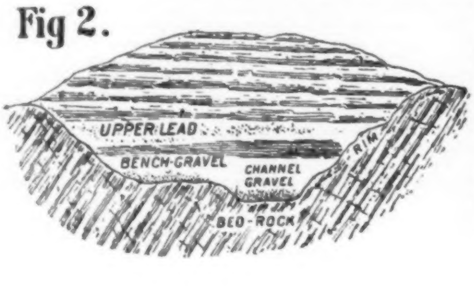


Fig 1.

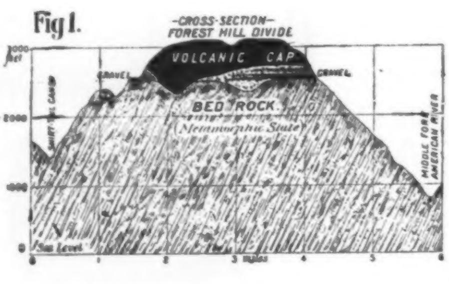


Fig 3.

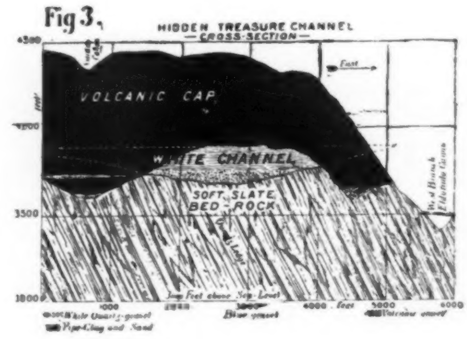
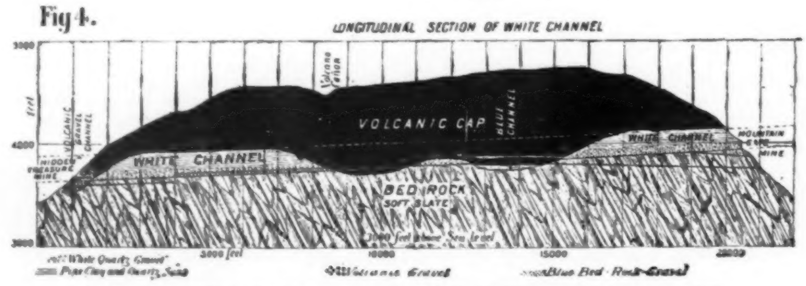


Fig 4.



DRIFT MINING CHANNELS ON THE FOREST HILL DIVIDE.

cut, forming eventually as the forks of the American River the deep canyons of the present day.

From the frequent displacement of the streams during the second period described, there have arisen various complications in the channel systems. Although the mining developments are extensive in portions of the district, it still remains a difficult matter to separate the channel systems of the second period, and it is not always easy to distinguish between those of the first and second periods. In a general way it may be said that the channels of the second period differ from those of the first as follows: Their beds are narrower, rims steeper, and accumulations of bed rock gravel incomparably smaller.

The following may be said concerning the gravels in the deeper channel bottoms, and their immediate volcanic cappings: The characteristic channel deposit of the first period consists of a large body of gravel of exclusively bed rock material, and a light cement capping; the characteristic channel deposits of the second period, either of a small body of bed rock gravel and a heavier cement capping, or of a large body of volcanic gravel and a heavy volcanic conglomerate and cement capping.

A continuous cap of so-called pipe clay generally indicates the first period.

Where one deep channel cuts across the deposit of another, the channel which does the cutting belongs, as a rule, to the second period. The channel which has been cut may belong to either period. A careful study of the immediate volcanic caps of the gravel deposits by a competent specialist in petrography may lead to important criterions in classifying the channels. It will be evident that Mr. Browne's opportunities have been mainly for a study of the topographical features.

There occur occasionally very large accumulations of bed rock gravel between the deposits of volcanic cement, which are evidently the result of the cutting and dislodgment of sections of the old deposit. (See Fig. 6; Fig. 5 is omitted.)

The upper body of quartz gravel shown in the figure is such an occurrence. It has not been explored to any great extent, and the limiting lines in this section are conjectural.

The section in Fig. 6 shows an interesting occurrence. In depositing of the volcanic material the stream was a small one. (See Fig. 7.)

These standing trees show also that the first flow of the cement was not torrential, though moving with a certain velocity. The existence of a current and its direction are plainly indicated by the structure of the deposit immediately surrounding the trunks of the trees.

The Weske channel is apparently one of the earlier channels of the second period. It is cut by a slightly deeper channel, which is filled to a considerable depth with a coarse, volcanic gravel, containing large, waterworn bowlders of lava, mixed with a certain amount of coarse bed rock gravel. The whole is capped with hard cement and conglomerate. By following the course of the Weske channel it will be seen that it, in turn, cuts and recuts the Paragon and Mayflower channels.

In certain districts in the State the ancient channel system, together with its dividing ridges, was completely covered by a broad lava cap or mantle prior to the starting of the modern channel system. There appears no definite indication of such a mantle in the district described by Mr. Ross E. Browne, in the State mineralogist's reports; on the contrary, the presumption is against it. Had the second period been closed by a broad, flat-topped lava mantle, completely covering the earlier divides, one should expect to find the modern channel independent of the cement channel in its course, occasionally cutting and occasionally avoiding the same without a definite guidance, and leaving as much of the old lava-capped divide as of the cement channel to form the present ridge. Such, however, is not the case on the Forest Hill Divide. The prospecting shafts and tunnels have invariably developed the existence of a trough-like depression under the volcanic cap. The ridge for 26 miles, from Tadpole to Peckham Hill, shows under the cap a practically continuous depression in the bed rock surface. There is good reason for regarding this as the main cement channel of the district.

It is difficult to establish satisfactorily the cause which led the modern river to avoid the older cement channel to so marked an extent. In picturing the periods, it has been assumed that the old river bed, or rather the valley, was filled with volcanic material to a level high up on its widespread rims, but not to actual overflowing; that the thick volcanic mud formed a more compact conglomerate of the heavier debris in the central line of flow, and a lighter and more sandy cement toward the shore lines; and that these conditions tended to divert the streams toward the marginal lines of the deposit. The streams would necessarily cut across the deposit at the juncture of the volcanic-capped tributaries.

There is offered no definite evidence in support of this assumption. It is made, in default of a better one, with the view of impressing the fact that the old cement channel has been avoided, to a notable extent, by the channel of the modern rivers.

Fig 6.

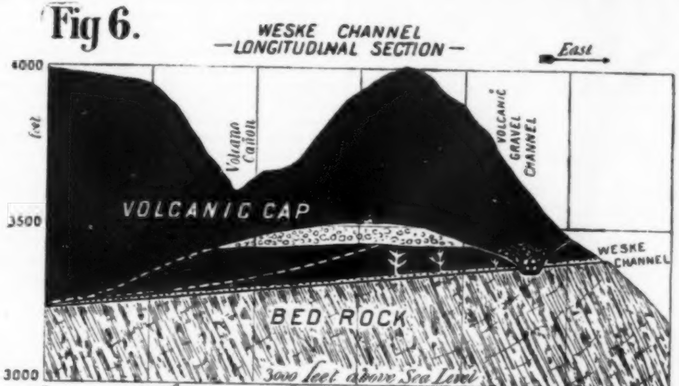
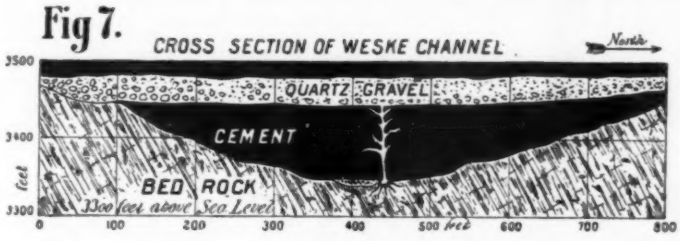


Fig 7.



BURIED TREES IN FOREST HILL DIVIDE DRIFT MINES.

Fig 8

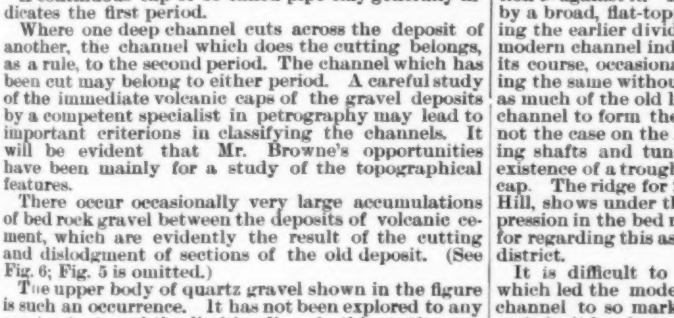
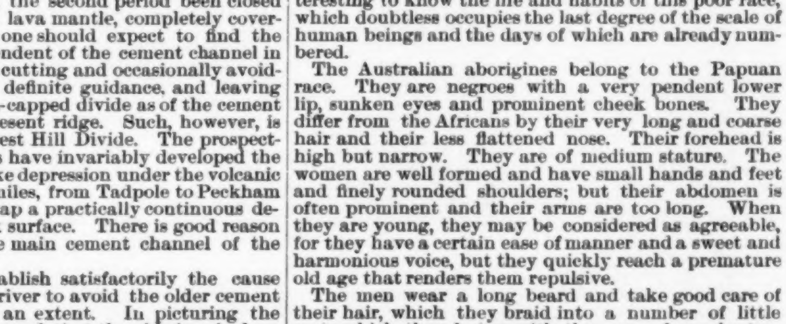


Fig 9.



DRIFT MINES OF THE FOREST HILL DIVIDE.

The cement filling the bed to a depth of 100 ft. is a more uniformly fine-grained sediment than is commonly encountered. It incloses a number of oak and cedar trees standing on the banks of the channel, with the roots intact in the gravelly soil and bed rock. One of these is a cedar nearly 100 ft. in height and 4 ft. in diameter at the base, and stands perfectly upright, and, considering its age, is in a surprising state of preservation.

Similar standing trees are found in the Bowen mine, in the same channel. These trees are immediately on the shore line of the shallow deposit of gravel, and show that for a few centuries at least before the de-

It is plain, however, that the construction of the ancient systems is very far from being so simple.

The following section (Fig. 8) shows the height of the present bed rock ridges. The rims of the old river bed must have been higher than these. The section here given is taken across the Golden River and Eureka claims. The existence of two deep channels is not absolutely determined. They are indicated by the pitching rims, but have not yet been developed.

Owing to small irregularities there is required the development of a considerable length of the channel to determine satisfactorily the average grade. However, disregarding the smaller tributaries, the exposed sections show, as a rule, a fair uniformity of grade—certainly as great a uniformity as the modern river beds. The accompanying longitudinal section of the divide shows the grades of the summit line, and of the ancient and modern channels, and the depth of erosion. The course of the ancient river was more sinuous than that of the ridge line, hence the grade in the section is somewhat greater than the actual grade. —*Mining and Scientific Press.*

AMONG THE ABORIGINES OF AUSTRALIA.

AUSTRALIA, situated between three oceans, and isolated in the center of an immense mass of liquid, is connected with other lands by a chain of volcanic islands forming a barrier that the Chinese have never dared to cross in order to establish themselves in the country. They have known, however, from the remotest antiquity, of the existence of this southern country, upon which are found traces of them.

The Dutch, installed at Batavia, visited its ports, but, finding no riches to exploit, retired before the anthropophagous aborigines and contented themselves with giving this continent the name of New Holland, which disappeared after the discovery of gold in 1851 to give place to that of Australia.

William le Testut, in 1540, figured for the first time the northern coast of Australia, which he had just explored. In 1788, Governor Philipp stopped at Botany Bay in order to land some convicts that he had brought from England, but, not finding the place favorable, left it on the day that La Perouse arrived there himself with the Boussole and Astrolabe, whence he sailed a few miles to the north to found Sydney. It was France and England, therefore, that began the exploration of Australia. We still find upon the west coast a series of names that are gradually being replaced by English ones, and that bear witness to the passage of our navigators in these regions. At the time of the revolution and the empire, France abandoned the contest and England installed herself as mistress of this immense island, for which no rival nation any longer disputed with her.

The aborigines that were found upon the new continent were very numerous and absolutely savage. Civilization, in forcing them back before her, has imposed upon them the sad fate reserved for the inferior races that are incapable of sustaining the terrible struggle for existence. They are on the eve of disappearing. In 1848, there were still three millions of them. At present there are scarcely two hundred thousand. In a near future we shall no longer have anything but a remembrance of them. It is therefore interesting to know the life and habits of this poor race, which doubtless occupies the last degree of the scale of human beings and the days of which are already numbered.

The Australian aborigines belong to the Papuan race. They are negroes with a very pendent lower lip, sunken eyes and prominent cheek bones. They differ from the Africans by their very long and coarse hair and their less flattened nose. Their forehead is high but narrow. They are of medium stature. The women are well formed and have small hands and feet and finely rounded shoulders; but their abdomen is often prominent and their arms are too long. When they are young, they may be considered as agreeable, for they have a certain ease of manner and a sweet and harmonious voice, but they quickly reach a premature old age that renders them repulsive.

The men wear a long beard and take good care of their hair, which they braid into a number of little mats which they fasten with the gum of eucalyptus, or fix to it, by means of yellow gum, kangaroo or human teeth, feathers, pieces of wood and dogs' tails. Oils of all qualities are very much in favor among them. Smeared over the surface of the body, they drive away mosquitoes. The men, in guise of ornaments, make very deep cicatrices in the skin. These they produce by cutting the flesh with a sharpened stone, and, in order to increase the depth of the marks, they keep the wound open by putting charcoal or clay into it.

In the women, these scars, fewer in number, serve solely to recognize the tribe to which they belong. They often cut the small joint of one of the fingers as a sign of mourning, while as for the men the mourning consists in decorating the body with wide stripes

made with yellow ocher. For certain ceremonies called the *corrobboorees* the stripes are red. In war the color adopted is white. They arrange these stripes according to their taste, surrounding their eyes with them and putting some at the level of each bone, in order to give themselves the aspect of a skeleton. When the young people reach the age of manhood, the custom in almost all the tribes is to pull one of their front teeth out of the upper jaw. The costume of the aborigines is very scanty, consisting solely of an opossum skin girdle.

They are a wandering people, a population of nomads, who find a lodging place every night in holes in the rocks or under a few branches of trees. If, however, they wish to stay a few days in some place, they build huts called *gunyahs*. These temporary shelters, which are conical, are constructed of stakes six or eight feet in height, covered with bark. They are of small dimensions, and it is impossible to occupy them except by sitting squat and bending over. These huts are placed back to back, so that each entrance commands a point of the horizon—an arrangement that permits of baffling surprises by the enemy.

They live on the products of their hunting and fishing, to which they give a relish with wild honey gathered here and there in the trees. To this effect, they climb in an original manner. They surround the tree with a flexible vine which they hold with their left hand. With the right hand provided with a sort of short pick called a tomahawk, they cut notches in the tree that serve, by putting the big toe therein, as a bearing point to give, with the two hands, a slight shock to the vine and make it ascend along the trunk. During the few instants in which the two hands are occupied, they place the tomahawk either in their girdle or between their teeth. They thus succeed in mounting very rapidly to the summit of the highest trees, even if the bark is not rough (Fig. 1).

Their canoes are made of tree trunks which they hollow out with fire. Sometimes they are made of wide pieces of bark united at the two extremities, and the fissures in which are closed with clay. They have a very peculiar way of calling to a certain distance in the woods. They utter a *coo-ee* with a certain inflection of the voice higher upon the second syllable. This cry extends to considerable distances. It constitutes so convenient a call that it is now adopted by all the inhabitants of Australia, even by the whites.

Family does not exist with them. They live in a state of the completest promiscuousness. The women belong to the entire tribe, and the child's father is all the men of the tribe. In the midst of this primitive state it is strange to find a very severe law that prevents consanguinity in unions. This law rests upon a system that consists in giving the children a name that belongs to them by birth. They do not take the name of their parents, but the name of the mother fixes that of her children in advance. All the sons of a woman called Maramba, for example, are named Kumbo and all the girls Ippatha—names imposed by law. All the tribe being thus named according to a principle, one makes use of it as a basis for the law of unions. This rule prevents a man from taking his sister, his stepsister, his niece or his aunt for a wife, and prevents marriages between cousins german when they are the children of two sisters.

The young man who wishes to take a wife must begin by attracting to himself the good graces of his future mother-in-law by sending her the products of his hunting, but he is not authorized to marry until after receiving the consecration of the Bora. The name Bora is derived from the word *bor*, which means "girdle of puberty." It is given to the adolescent who has reached the age of manhood. This *bor* possesses magic powers. Thrown upon an enemy, it has the power of communicating diseases to him. It is the great national institution of the Australian savage. It is the ceremony of the initiation of the duties and rights of man. The sacred character of this immemorial rite and the obligations to submit to it are very strongly impressed upon the mind of the young aborigines. Even if they are in the service of the squatters, and have for a long time broken with their own people, they appear to be irresistibly impelled to go to submit themselves to the ceremony when the time comes.

The following is the legend: A long time ago the creator, Baiame, commanded men to guard the Bora and gave them the Dhurumbulum or sacred club. The Bora is held as soon as there are a certain number of young people of age to be admitted to it. The council of the tribe selects the location for the Bora and appoints one of its members as director of the ceremonies. The neighboring tribes are invited to the latter through a herald carrying a boomerang and an arrow from which is suspended the skin of a padymelon. The place designated is consecrated to Baiame. The trees are ornamented with allegorical figures of serpents and birds, formed with tomahawks.

The men quit the camp, leaving the women, children and young men behind, and proceed to the place of

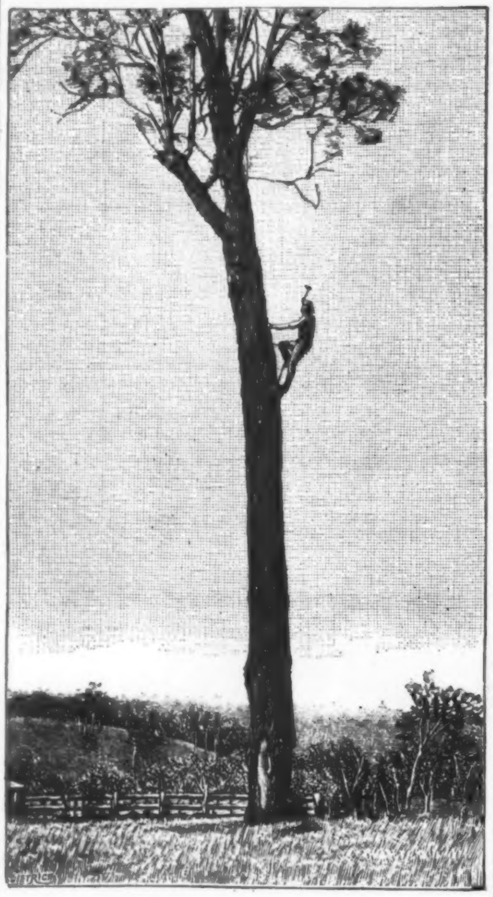


Fig. 1.—AUSTRALIAN ABORIGINE CLIMBING A TREE.

the Bora. At the end of a few days they return, simulate an attack upon the camp and carry off the adolescents.

In order to undergo initiation, the candidates must live for seven months according to a very severe rule, eating only certain kinds of food and living apart from any society. They remain at the Bora for seven days under the surveillance of three old men, after which one of the front teeth of their upper jaw is pulled. They receive a severe flogging, which they must bear stoically, and they are fed upon the most repugnant things. It is then forbidden them to approach a woman within less than 2,300 feet for four months. Once only it is permitted them to perceive the women through a dense smoke of green wood. Finally, a make-believe fight completes the initiation. Starting from this moment, the youth has the right to exercise his privileges of manhood. He can eat kangaroo and emu and select those who will be his wives.

During the intervals of the Bora, the old men instruct the young men upon the traditions of the tribe, such as the laws of consanguinity in marriage, which, if not observed, entail the death of the guilty one.

The ceremony of the Bora is the great system of education through which the customs of the tribe are transmitted from generation to generation. Among such traditions exist the various dances or corrobboorees, which have a very particular character of wildness. The men carry their weapons of war in their hand and are painted red and white. The affair takes place at night. The men run in a circle around a burning log, and, balancing the head in cadence, loudly yell. Their eyes are fixed and brilliant and they reach a remarkable degree of excitation, during which they strike their head with their weapons until they bring blood, losing the idea of any feeling of pain and reality.—*La Nature.*

Fig. 2.—AUSTRALIAN MAN.

Fig. 3.—AUSTRALIAN WOMAN.

Fig. 4.—NATIVE OF NORTHERN AUSTRALIA.

DECORATIVE PLANTING.

Decorative planting gives more than anything else in landscaping to perspective vistas their life and extensions. Generally, planting in miniature parks should exclude the largest trees, for their nature deems justly to adorn the whole surface of the earth; some oaks or sugar maples, or tulip trees, or chestnuts or the like, when full grown, are large enough to cover a whole acre of land and make pygmies of ordinarily large dwellings; so in a small park of a few acres there should be planted trees which, when full grown, will not reach more than 15 to 20 ft. in height, and there are numerous such species to be had in our nurseries. Then buildings will not vanish at the side of the giant trees, and human beings, nevertheless, will have plenty of necessary shade.

Small hills will make themselves respectable looking, and the whole scenery be in harmony with miniature reproductions of natural creations, the general idea of which has been advanced. In the arrangement of long vistas especially wonderful effects can be got, if there be understood the rightly setting out skeleton trees and surrounding them with proper accessories; the robust dark-leaved trees set in clusters, many times two or three trees even planted in the same hole, will make more effective and *pittoresque tableaux* than when every tree has the whole proper space to develop its full capacity of growth; and to unite the underbrush with the high growth trees of every needed size, especially such as be of 10 to 15 ft. in height, when full grown, may be set before the smaller ones are planted; thus the agroupments will not look like immense balls, but on the contrary disclose here and there overhanging with slender and graceful specimens to break the uniformity and contours of the clusters, and make good taste and refined nature combine in deceiving, happily, everybody, in respect of the true extent of the combinations of smaller trees and medium sized underbrush. But, in any case, these groupings should not finish in incised contours only; here and there should be seen specimens of trees in single form or in combination of two or three, like *vedettes* deployed before a compact army.

In no way can decorative planting be of greater effect than if one so selects the warm and cold colored leaves of different trees as to bring out the utmost harmony in the living picture one is creating; take, for instance, of the warm-colored leaves some mock orange shrubs and snowballs in the foreground, and some silvery-leaved shrubs in the incisions behind, with some golden-chains hanging gracefully in front of some dark-leaved lilacs; and even some perennial flower plants, in the boundary of the groups, will make with their differently colored flowers such contrasts or harmonies, just as the artist painter comprehends how to combine the different groups of his picture into one harmonious composition; and an idea of my suggestion may be had. Thus far I have referred to the deciduous trees: concerning the evergreen trees there should be remarked that in nature the *pines* and *spruces* ornate the mountains and belong to the wildest part of natural scenery. It also will be seen that in young forests often pines and spruces grow together with deciduous trees, but as soon as the woods develop either the needle trees or the deciduous have to succumb, depending on the fertility of the soil. A fertile and stiff soil will give the deciduous trees the strength to overgrow the needle trees and kill them, while a sterile, sandy and stony ground will carry the palm for the needle trees.

When planting our small parks we should therefore do just as nature has advised. Otherwise the one or the other have to die out in a short future. We should also be careful not to plant needle trees too close to our dwellings, because there is no greater promoter of fires than needle trees, whereas deciduous trees are the best safeguards against fires.

If we want to follow nature's advice and obtain good effects in our *miniature parks*, we should plant needle trees in clusters of three, five, up to fifteen on small knolls on either side of our vistas, but never in the low grounds.

Even with them the color of the needles plays a great role. We have such ones which are nearly yellow, other ones dark green, while again others are perfectly silver-white.

But we have other evergreens which especially should be used around our buildings, namely evergreen-leaved trees and shrubs, which are the very finest to be planted at the very threshold of our houses, because they decorate them both winter and summer.

Concerning the evergreen thuyas, they can be placed in lower grounds, as they, in the wilderness, grow in the swamps, and will make the same good effects there as the needle trees will make on the heights.

Even the flower department has its natural harmony. How infinitely more beautiful is not the meadow with its wealth of sweet-smelling flowers than that short cropped lawn, where nature has been deprived of her lovely *flora*, and the monotonous emerald green is seen in every direction as before mentioned; so it is also with our flower gardens. How much more inviting to love of nature the old fashioned *rabatts* with their thousands of different species of most interesting and instructing plants, instead of these eternally identical *coleuses* and *pelargons* and pyreatrums, to the thousands of each species, stuffed up into colossal puddings along the roads, without any *motif* for their emplacement. But worse than even these are those *perukes* of leaf plants which are continually under the barber's shears; whereas the tropical *monocotyledons*, if located on the right spots and in outstretched and incised forms, are among the best ornaments, even in the park proper.

Carpet bedding belongs to architectural terraces and flower gardens, but when it usurps the functions of natural scenery it should be considered time to call a halt. Carpet bedding is the only fashionable flower show at present, and entirely tasteless besides, or in front of our days craziness for the middle-aged style of architecture, which latter rather would call for some robust and rocky wilderness instead of too extensive attendance. Still while *carpet bedding* is the only modern flower show at present, it is not difficult to find the reason for its domination; it pays the gardeners so well that it would be a ruin for them to plant perennial flower plants, or to sow annually seeds which can comparatively be had for a song. Even the lovely *rose gardens*, with their thousands of varieties of finest roses, and overshadowed by the rich flowering climbing roses, had been nearly exterminated. Same is also the case with these so highly interesting alpine plants, which surely must be remembered by every lover of botany, but which are now not any more to be seen, much less *en vogue*. And yet, in one word, the capacities of nature for suggestions to man as to how he shall beautify his habitations are infinite and instinctively beautiful, and it is in landscaping that they are brought, one and all, tribute to man's happiness; laid as treasure at his feet to enrich his life with that wealth of which nature herself is the only producer and conserver, and of these capacities I have given herein a notion, merely; their study is as endless and as endlessly beautiful as are themselves.

Brooklyn. KNUT FORSBERG.

THE HORTICULTURAL PALACE AT THE CHICAGO EXPOSITION.

THE glass palace designed for the horticultural exhibit is, unquestionably, one of the finest structures of the Exposition. It has an especial claim on the interest of Germans because its contents, taken *en masse*, represent the work of Germans more completely than the exhibits of any other building; for most of the gardeners who arranged the exhibits in and about the Horticultural buildings are Germans. The exhibition of fruit (fresh and preserved), seeds and the various pretty devices of the landscape gardening combine here to form a picture that is uncommonly rich in color, although here and there—as far as the collection of fruit is concerned—rather tiresome. Incidentally, the smart Americans have sought to prevent weariness by offering a prize for guessing the number of single fruits in certain gigantic groups. In the central portion of the palace palms constitute the chief decoration, but there are also numerous cacti, many of which are specimens of rare beauty. In the two northern extensions of the main building we find extensive exhibits of fruits and flowers, and also specimens of landscape gardening. Our artist, E. Limmer, has shown in the accompanying engraving a masterpiece of Japanese landscape gardening. It is a park in miniature, with a number of Japanese dwarf trees, among which is a little pine from the imperial garden in Tokio and a skillfully dwarfed *Thuya obtusa*. The other garden decorations correspond with the little trees.—*Gustav Quade in Illustrirte Zeitung.*

THE WORLD'S COLUMBIAN EXPOSITION—THE JAPANESE GARDEN.

THE GREENHEART TREE.

(*Nectandra Rodiœi*, Schomb.)

THE Biberu or brown greenheart tree of British Guiana (*Nectandra Rodiœi*, Schomburgk) is one of the most noted and valuable timber trees of tropical America. It belongs to the natural order *Laurineæ*. According to Trimen, Miquel following Nees doubtfully refers it as a local variety to *Nectandra leucantha*, Nees, native of Brazil; but the figure he gives of that species ("Stirp. Surinam," t. 58), which is quoted by Meissner for *N. Rodiœi*, appears very unlike the Demerara greenheart. The tree probably grows only in British Guiana, but is found abundantly there on rocky soils at a slight elevation in forests extending 20 to 100 miles inland from the coast. The tree often reaches a height of 60 to 80 feet, with an erect trunk, bare below and branched only at the summit. The bark is smooth, whitish gray; the youngest branches are covered with a fine tomentum. The leaves are sub-opposite, on short peduncles, channeled above, about six inches long, oblong-oval, acuminate, entire, very shining above, rather paler beneath. The flowers are small, in axillary panicles. From the habit of growth of the tree the flowers are difficult to obtain. They possess a fragrant odor resembling jasmine. The fruit is roundish ovoid, very blunt or subpyriform. The seed is solitary, very large, filling the fruit.

The only figure of this plant so far published is given by Bentley and Trimen (*Med. Plants*, t. 219). The bark of the greenheart possesses tonic and astringent properties, and it is known as Bebeeru, Biberu or greenheart bark. It has no marked odor, but its taste is strongly and persistently bitter and very astringent. From it is prepared sulphate of Beberia, a salt, if obtained according to the directions of the British Pharmacopœia, occurring as dark brown, thin, translucent scales, yellow when in powder, with a stong bitter taste, soluble in water and alcohol, and entirely destructible by heat. As an astringent tonic in general debility and chronic conditions of the alimentary mucous membrane it appears to be specially suitable (Bentley and Trimen).

Of other uses of this plant it may be mentioned that the Indians in time of scarcity use the seeds in the preparation of a kind of bread. The wood of the greenheart is, however, most valuable. It is hard and durable, and in demand for shipbuilding and other purposes. Its merits in resisting the attacks of the teredo have lately been strikingly shown in some experiments undertaken in Port Said in connection with the works of the Suez Canal. The correspondence on the subject having been obligingly communicated to Kew by the Secretary of State for Foreign Affairs, it is published in the *Kew Bulletin* for the purpose of drawing further attention to the properties of this valuable timber tree.

BRITISH DIRECTORS, SUEZ CANAL COMPANY, TO FOREIGN OFFICE.

PARIS, February 15, 1893.

MY LORD: We have the honor to transmit to your lordship herewith a copy of a letter which has been received from the Suez Canal Company's chief engineer in Egypt as to some experiments which have been made at Port Said with regard to the resistance offered to the ravages of the borer worm (taret) by various kinds of wood.

Three piles of pine, oak and greenheart respectively were placed in the arsenal basin at Port Said two years ago, and have recently been examined.

The result as shown on the sketch inclosed is that while the pine and oak are almost entirely destroyed, the greenheart has suffered no injury whatever.

We have, etc.
(for the British directors).
(Signed) H. AUSTIN LEE.

The most honorable the Earl of Rosebery, K.G., etc.

EXPERIMENTS WITH THE WOOD OF THE GREENHEART.

ISMAILIA, January 24, 1893.

Monsieur F. De Lesseps, President-Directeur de la Compagnie a Paris.

Referring to my letter No. 8,831, dated December 26, 1891, I have the honor of informing you that we have had the piles of pine, oak, and greenheart taken up that were put in place January 15, 1891, at the north-east corner of the arsenal basin at Port Said, so that we could study the resistance of the wood of the

greenheart compared with that of other kinds of wood used.

You will find inclosed a sketch giving the form and dimensions of the immersed parts of these piles.

The result of the examination of these piles (which were 0·250 m. square when they were put down) was:

1. The pile of greenheart showed no traces of the borer worm (taret) or deterioration of any kind.

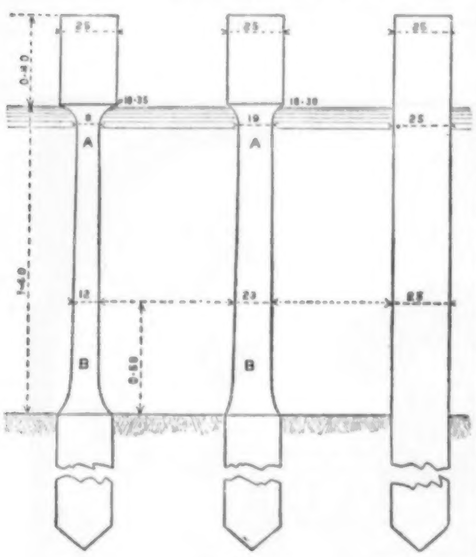
2. The entire submerged part of the oak pile was very much injured by the worm, and it had penetrated so far into the thickness of the wood as to reduce the part affected to a section of 0·180 m. × 0·180 m. at A in the annexed sketch, and to 0·200 m. × 0·200 m. at B.

3. The pile of pine was so eaten by the worm as to be useless. The affected part was reduced at A to a section of 0·070 m. × 0·070 m., and at B to 0·140 m. × 0·140 m.

These experiments have, therefore, demonstrated that the wood of the greenheart offers much greater resistance to the worms than that of the oak or pine.

In order to determine whether it would be advantageous to substitute the greenheart for oak and pine in submerged structures, we would have to know the cost per cubic meter delivered at Port Said, so as to be able to compare this price with the price of oak and pine. Believe me, sir,

LAMASSON,
Chief Engineer of the Company.



Pine. Oak. Greenheart.

The following detailed information respecting the characteristics and uses of greenheart timber may be usefully appended:

"The greenheart is an exceedingly valuable tree, yielding timber of perfectly straight growth, of from 24 to 50 feet in length and 12 to 24 inches square.

"The wood is of a dark greenish or chestnut color, the center part being often nearly black; it, however, varies slightly, and the darker kinds are considered the best in quality. It is clean and straight in the grain, very hard and heavy, tough, strong and elastic. In a transverse section it resembles a cane in being very full of minute pores, and the concentric layers are only in rare instances distinguishable.

"The heartwood is considered very durable, and is generally believed to be proof against the ravages of the worm when used for piles or other purposes under water, a property which would greatly enhance its value if it could be relied upon; but its immunity under such circumstances is thought to be doubtful.

"Of the durability of the greenheart timber, we have had sufficient evidence in the large stock of this wood kept in the royal dockyards, where it stood the test of many years' exposure to the weather without being in any but the least degree affected by it. At Woolwich, the only place, I believe, where any attempt was made to protect it for preservation, the experiment to some extent failed, the ends of the logs splitting open rather more in the covered stacks than in those which were left exposed, while, in other respects, there was absolutely no difference observable between the two parcels.

"It is characteristic, however, of the greenheart timber to split in this way, and to open clean across the pith in seasoning, there being frequently two such splits crossing each other at nearly right angles, and cleaving the log, at the end, into four segments; but these do not usually extend more than two or three feet up from the end.

"This serious defect is, to some extent, compensated for by the fact that the logs do not split and form deep shakes along the sides in the seasoning, as do most other woods; so that there is not, after all, more than the ordinary amount of waste in the conversion of this kind of timber. Further, it is remarkable for its freedom from knots, and also for its general soundness, the only defect, beyond the splitting of the ends, before mentioned, being a cross fracture of the longitudinal fibers, which is occasionally seen, but can seldom be detected before the log is under conversion.

"The alburnum, or sap of this wood, is of a dark greenish color, and differs so little in appearance from the heartwood, that it is often difficult to distinguish the one from the other. In quantity it is usually excessive, frequently amounting to a fifth, and sometimes even to a third, of the diameter of the tree. Few people, however, regard it when appropriating this timber to works of construction.

"Owing to the difficulty of distinguishing the sap, many either dispute its presence altogether, or assert that if it exists it may be safely employed the same as the sap of lignum vitæ; this is, however, by no means certain, as I have found that if it is placed in any damp or imperfectly ventilated situation, it decays much sooner than the heartwood; but if used under more favorable circumstances its durability is very great.

"In connection with this question a merchant and importer of greenheart timber said upon one occasion, when we had a parcel under survey, that he was confident a certain log had no sap wood upon it, for if it had, it would be liable to the attack of a small worm, but that the worm would not touch the heartwood. The log referred to was accordingly tested by cutting off a thin cross section, and upon examination of the piece, there were found in it several marks or traces of the worm, which had penetrated to the depth of 2 to 3 inches; the heartwood, or duramen, had not, however, been touched. The gentleman at once admitted that, with such evidence, he would take it as conclusive that there was sap to the depth of 3 inches on the log, but that its appearance had entirely deceived him.

"The case was no doubt exceptional, as the worm is very seldom seen in this wood.

"Greenheart is extensively employed in shipbuilding for keelsons, engine bearers, beams, shelf pieces, etc., and for planking. It is also used for piles, and many other purposes, but its application to the domestic arts is somewhat limited by its great weight.

"The strength of this wood exceeds that of most others, whether it be tried by the transverse or tensile strain or by a crushing force in the direction of its fibers. Tried by the latter process, it exhibits a peculiarity unshared, I believe, by any other timber except Sabicu. It bears the addition of weight after weight without showing any signs of yielding; and, when the crushing force is obtained, it gives way suddenly and completely, with a loud report, nothing being left of the pieces but a loose mass of shapeless fibers.

"The greenheart timber is not usually hewn in the perfect manner that teak, mahogany, and many other woods are when prepared for shipment to the markets of this country, but comes from Demerara only partially dressed, a great deal of wane being left upon the angles. The butts are also almost invariably left with the snapped ends, as prepared for drawing out of the forest, instead of being cut off square. Its form should therefore be considered with the price quoted per load, as it will not compare favorably with well-squared timber."—*Timber and Timber Trees, Laslett*, 1875, *p.* 151.

DO PLANTS THINK?

UNDER this heading an interesting paper recently appeared in the *Newcastle Weekly Chronicle*. The freaks and marvels of plant life are subjects which have engaged the attention of the botanists for many years, and though their investigations gave rise to much speculation, some interesting facts have also been ascertained. Some of these are summarized in Dr. M. C. Cooke's book on this subject. A story of one of the most interesting freaks of vegetable life is told by Mr. Edward Cooper, of Santa Barbara, California. On reading this story one may well ask, Do plants think? Mr. Cooper considers they do, and he puts forward reasons for thinking so. Through Mr. Cooper's garden there ran some years ago a sewer made of redwood timber. This sewer was again cased by an outside sewer, which in course of time became partially decayed. Across the sewer there was built a brick wall many feet in height, and in such a way that it was pierced by the inner sewer, which it enclosed tightly, while the outside sewer ended abruptly against the wall. As already stated, the outside casing had in course of time become decayed, and an eucalyptus tree, standing some sixty feet away, had taken advantage of this, and sent one of its roots to the coveted spot in as direct a line as possible. Here the root entered the outside sewer, and followed its course as far as it could. At last it came to the wall, which shut off its course, the inner sewer being perfectly tight. But on the other side of the wall the sewer and its double casing continued, and the eucalyptus tree evidently knew how to get there. Some three feet high in the brick wall there was a little hole, one or two inches in diameter, and this the eucalyptus tree appeared to be aware of, as its root began to climb the brick wall and face the sun and wind until it found the hole, through which it descended on the other side, entering the sewer again and following it along as formerly. Taking this statement as being accurate in every respect, we may well put the questions asked by the writer of the paragraph: "Was ever such instinct known before, or are similar traits in plants of daily occurrence without our knowledge? How did the tree know of the hole in the wall? How did it know that the sewer was on the other side? Did it smell, and if it did, how could it direct the roots to go and find the place with such precision?" There is, of course, another explanation of this curious phenomenon: the roots of any plant grow always unerringly in the direction of its food, just as those of the eucalyptus tree did.

The question arises, What is thought? What is meant by thinking? A modern writer has remarked that thought is the result of nature—of the outer world—first upon the senses—those impressions left upon the brain as pictures of things in the outward world—and these pictures are transformed into or produce thoughts, and as long as the doors of the senses are open thoughts will be produced. Do plants think in this sense? The botanist examines the structure of a plant and ascertains its ways of living, how its blood—the sap—circulates, and how it breathes; but behind these things he has failed to penetrate, and is possibly scarcely prepared to regard the plant as a sentient being. Whoever looks at anything in nature, thinks. Whoever hears any sound, or any symphony, no matter what—thinks. Whoever looks upon the sea, or on a star, or on a flower, or on the face of a fellow-man—thinks, and the result of that look is an absolute necessity. The thoughts produced depend upon the brain, upon experience, upon the history of one's life. Can a plant be said to think and be affected in this manner?

In their observation of the gyrations of plants, in the case of the heliotropes or sunflowers, which conspicuously turn themselves toward or from the sun, in the action of twiners and climbers, and of sensitive plants in their sleep, their methods of dispersion, of mimicry and luminosity, we see plants exhibiting faculties coming very near to what we term reasoning; but they may do all this in a merely mechanical way, and without being actuated by anything like thought directing these movements.

It is a hasty conclusion to assert that brain is essential to the evolution or quality of thought. Thought is a necessity, and thought depends upon the brain. Each brain is a kind of field where nature sows with careless hands the seeds of thought. Some brains are poor and barren fields, producing weeds and thorns, and some are like the tropic world where grow the palm and pine—children of the sun and soil. But it is asked, Does a man or an animal think when he or it does one thing or declines to do another? Volition would seem to be surely involved in the process of choice. We know that plants and animals persistently decline to do certain things, and persistently do others, as if by the power of volition. What moved the eucalyptus of Santa Barbara to leave the redwood covering of a sewer and creep to a hole in a brick wall three feet away, go through it, and again turn for sustenance to the sewer? Did man or animal ever discover finer sagacity in self-preservation?

As bearing upon this subject, we have the benefit of another testimony, the writer stating: "In the yard before the window near which I sit, is a fine healthy plane tree, which springs from the ground about nine feet from the tall gable of a coachhouse and hayloft, and higher than the gable; it has grown to the height of from forty to forty-five feet from the root. On every side but from that toward the wall issue branches equally as long as on the other sides, but they deliberately turn round both the corners, but not a twig ever touches the gable." This characteristic can, no doubt, be accounted for by the natural tendency of the branches to seek the light; but the why of the act of volition is doubtless hidden with much of the silent mystery of the plant's nature.

This is an exceedingly interesting subject, and it is to be hoped the publication of the foregoing will have the effect of leading to some interchange of opinion in reference thereto. Gardeners are often closely observant men, and they are doubtless in possession of the knowledge of incidents which may throw additional light upon the problem—Do plants think?

R. D.

INTERNATIONAL CONFERENCE ON AERIAL NAVIGATION.*

By O. CHANUTE.

IT is well to recognize from the beginning that we have met here for a conference upon an unusual subject; one in which commercial success is not yet to be discerned, and in which the general public, not knowing of the progress really accomplished, has little interest and still less confidence.

The fascinating, because unsolved, problem of aerial navigation has hitherto been associated with failure. Its students have generally been considered as eccentric, to speak plainly, as "cranks," and yet a measurable success is now probably in sight with balloons; a success measurable so far that we can already say that it will probably not be a commercial one; while as to flying machines proper, which promise high speeds, we can say that the elements of an eventual success, the commercial uses of which are not yet very clear, have gradually accumulated during the past half century.

The truth of these assertions, which will be justified further on, seems to indicate that it is not unreasonable for us as engineers, as mechanics, and as investigators to meet together here in order to discuss some of the scientific principles involved and to interchange our knowledge and ideas.

The present is, I believe, the third international conference upon aerial navigation. The second took place in Paris in 1889, and a fourth is projected to take place in that city during the exposition of 1900.

The conference of 1889 undoubtedly forwarded the possible solution of the problem, by making the public aware that a number of sane men were studying it in various parts of the world, by making these men acquainted with each other's labors, and by disseminating information concerning the scientific principles involved, the mechanical difficulties to be surmounted, and the practical details of aerial construction generally. Probably as a consequence of this, very considerable advance has been made during the last four years, as will be indicated hereafter, and a number of promising proposals are now in progress of experiment and development.

We may fairly expect similar results to follow from the present conference. We may hope to collate here considerable knowledge concerning the scientific principles involved, to gain information concerning the latest researches, and to establish some concert of action.

Indeed, we shall begin our proceedings with the presentation of a paper by Prof. Langley concerning what may be said to be the exposition of a new natural law, hitherto but dimly suspected, which seems to hold out promise of important consequence.

We neither expect nor desire the presentation here of new projects for navigable balloons or for flying machines. We have endeavored to secure instead the statement of general principles and of the results of actual experiments; as facts and positive knowledge are deemed more instructive than projects or speculations.

Success, when it comes, is likely to be reached through a process of gradual evolution and improvement, and the most that we can hope to accomplish at present is to gain such knowledge of the general elements of the problem as to enable us to judge of the probable value of future proposals, both as mechanical and as commercial enterprises.

More important still, we may, perhaps, help to enlighten a number of worthy but ill-equipped inventors who are retrying old experiments, with no proper understanding of the enormous mechanical difficulties involved.

As a preliminary to our proceedings it will probably be interesting to you to have a brief survey of what has already been accomplished, both with balloons and with flying machines, and of the advance which has been achieved since 1889.

* Presidential address delivered at the World's Columbian Exposition, Chicago, 1893.

As regards navigable balloons, the latest reliable information is probably contained in an interesting and carefully prepared paper, read by Mr. Soreau, C.E., before the French Society of Civil Engineers, in February last, and discussed at the April meeting of that society.

You know that it has been abundantly proved that elongated balloons of large size can be made sufficiently stiff by internal gas pressure to stand driving at low velocities. The best speed hitherto obtained in any public trials has been fourteen miles per hour, which is quite insufficient to stem the wind upon any but rare occasions.

This speed was achieved by Commandant Renard, of the French Military Aeronautical Department, in 1885. The balloon was 165 ft. long and 27½ ft. in diameter, carrying an electric motor weighing 1,174 lb., which developed nine horse power. The motor, therefore, weighed 130 lb. per horse power.

Now the French technical papers announce, and Mr. Soreau confirms, that during the past winter Commandant Renard has been constructing a new war balloon, 230 ft. long and 42½ ft. in diameter, which is provided with a new motor, said to be of 45 horse power and to weigh, with 10 hours supplies, between 2,640 and 3,080 lb., or at the rate of about 66 lb. per horse power. With this apparatus and with a screw some 30 ft. in diameter, it is said that Commandant Renard expects to obtain a speed of 24½ miles per hour, and this will enable him, for about three-quarters of the days in the year, to stem the winds that blow.

Granting that the statements made about the motor are true (and there is nothing improbable about them, as we shall presently see), and also that the motor (the details of which are kept secret) shall not break down upon trial, I see no good reason to doubt the attainment of the speed estimated, and we may learn any day that it has been performed; although it is understood that the French authorities are maintaining such secrecy as they can concerning this new war engine.

But the Germans also, as well as several other European nations, are said to be in possession of navigable war balloons, and should war break out in Europe (which heaven avert), we might be very soon made aware of the fact that speeds of twenty-five miles an hour are practicable.

I have no doubt about it myself; but the attainment of this moderate speed requires very large and, therefore, costly balloons, which carry very few passengers, and it is clear that while such craft may be justified by the exigences of war, they cannot compete, commercially, with existing modes of transportation.

The difficulty with navigable balloons is that they must be of very great dimensions for even moderate speeds and very light useful loads. As the cubic contents of the gas bag increase at a higher ratio than the surface of its envelope, the relative lifting power increases with the size, and, therefore, a more powerful motor can be taken up, and more speed attained, but we soon reach the limits of practicability.

The new French war balloon is 230 ft. long (as large as a lake steamer), and it will carry but three or four passengers, at twenty-five miles an hour, so that it is difficult to conceive how, if they be made of sufficient size to carry a score of passengers, such enormous and frail craft can be handled, housed, or operated without peril of casualty or disaster.

The conditions as to resistance, lifting power, propellers, and motors are now pretty well known, the speeds can be calculated with approximate accuracy, and, while improvement can doubtless be achieved in the energy of the motor, in the efficiency of the screw, and especially in the form of the navigable balloon to diminish the resistance, it may be affirmed with confidence that railway express train speeds cannot be attained with balloons of practicable dimensions. They may be used for war purposes, or for exploration, but while we may say that the balloon problem is approximately solved, we may also say that the solution does not promise to become a commercial success, or to yield a large money reward to inventors.

With artificial flying machines proper, should a practical one eventually be developed, very much higher speeds may be expected. The pigeon flies at 60 miles an hour, the duck at 90, the swallow at 125, and the martin is said to flash through the air at something like 200 miles an hour. Professor Langley has lately shown that, within certain limits, high speeds through the air will be more economical of power than low speeds, and recent advance in light steam engines seems to have reduced them to a less weight per horse than is generally thought to obtain with the motor arrangements of birds. It seems, therefore, not unreasonable to entertain the hope that man may eventually achieve a mechanical success (if not a commercial one) in the attempt to compass a mode of transportation which so strongly appeals to the imagination, and that it may result in greater speeds than pertain to our present journeyings.

The mechanical difficulties in obtaining safe support from so intangible a fluid as air are, however, so great that men would long ago have given up the attempt if it had not been for the birds. But then there are the birds, and some of them, at least the sailing birds, concerning which you will hear something in some of the papers to be read here, seem to be able to soar indefinitely upon the wind with no muscular effort whatever, so that the argument that has been made that man cannot hope to float his greater weight than theirs upon the air would seem not to be well founded.

But, as already stated, the mechanical difficulties are very great, and it is not surprising that they should have deterred many men competent to advance the solution of the problem from considering it at all, and that it should have mainly been left in the hands of the more imaginative and ill-informed inventors, who, with imperfect knowledge of the elements of the problem, believe that success is to be achieved through a single happy thought.

It is a mistake to suppose that the problem of aviation is a single problem. In point of fact, it involves many problems, each to be separately solved, and these solutions then to be combined. These problems pertain to the motor, to the propelling instrument, to the form, extent, texture and construction of the sustaining surfaces, to the maintenance of the equipoise, to the methods of getting under way, of steering the apparatus in the air and of alighting safely. They each constitute one problem, involving one or more solutions, to be subsequently combined, and these are the elements of success already alluded to as having gradually accumulated, which I propose to pass in review, more particularly to appreciate what has been accomplished since 1889.

First, as to the air resistances and the support to be obtained from its inertia, we have the magnificent labors of Professor Langley, published in 1891, showing by careful experiments that something like 200 pounds can be sustained in the air by the exertion of one horse power. One-half of this weight has already been supported per horse in some experimental machines.

Then, as to the motor, Mr. Maxim has recently announced that he has constructed two steam engines of 300 horse power, which, with the engine proper, the boilers, pumps, generators, condensers and the weight of water in the complete circulation, weigh but eight pounds to the horse power.

With respect to the propelling instrument, Mr. Maxim has, since 1889, made a great many experiments with aerial screws. He finds, like Commandant Renard before him, that some forms are very much more effective than others, so that the coefficient of the efficiency, which was less than 35 per cent. in the earlier aerial serial screws, may now be said to be at least double this amount.

On the other hand, Mr. Hargrave, who now has built and experimented some eighteen different flying machines, all of which fly, says that he has obtained equal propulsive effects from screws and from beating wings, although he rather prefers the latter. A paper from him, giving the results of his latest experiments and describing his steam engine and boiler, which weigh only 10·7 pounds per horse power, will be submitted to this meeting.

As to the best form, extent, texture, and construction of sustaining surfaces, there is yet considerable uncertainty, but there will be submitted here two papers upon materials of aeronautical construction, one by Professor Thurston, and the other by Mr. Grorosland Taylor, which are well calculated to advance knowledge on this subject, while the experiments of Mr. Phillips in England, a few months ago, have shown that with peculiarly shaped blades of wood, about 72 pounds per horse power can be supported in the air.

The equipoise is, in my judgment, one of the most important problems yet to be solved in aviation. No success is to be hoped for unless the apparatus is stable and safe in the air, safe in starting, in sailing and in alighting. Three quarters at least of past failures can directly be traced to lack of equilibrium. This problem seems to be in process of solution, and I may mention in this connection that during the summers of 1891 and 1892, Mr. Lilienthal, of Berlin, has been gliding downward through the air, almost every Sunday and sometimes on week days, upon an aeroplane with which he expects eventually to imitate the soaring of the birds, when he has learned to manage it safely.

Several of the papers to be read here propose various methods of first acquiring this necessary skill, for first learning to fly under safe conditions before venturing to launch forth in the air. This bird science seems to be the first requisite, for safety is indispensable, and it may not be secured in free air until skill has been acquired in handling a machine.

The problems of starting up into the air, of steering and of alighting safely upon the ground, cannot yet be said to be in process of solution. Various methods have been proposed for getting under way, the principal of which have been to gain speed upon the ground, or to get a lifting action from rotating screws, but neither has as yet been practically demonstrated as quite practical upon a working scale.

For steering it has generally been proposed to employ two rudders, one vertical and one horizontal, but it yet remains to be known whether they will prove quite effective under the varying circumstances of flight.

The lighting upon the ground is likely to prove the most difficult and dangerous of the problems to be solved. It has been much too little considered by would-be inventors of flying machines, and may long prove a bar to the success of such apparatus; for nothing but direct experiment, and that of a perilous kind, will determine how this operation can be successfully performed.

I hope, however, that you will agree with me that some of the elements of success have gradually been accumulating, and that there has been real, substantial advance within the last few years. There is still much to be done, but a number of experimenters have each been working on one or more of the several problems involved, and they have made it more easy for others to forward the general solution still further.

From this brief review of recent progress it would appear less unreasonable than it seemed a few years ago to hope for eventual success in navigating the air, and it may now be reasonably prudent to experiment upon a small scale, particularly if the inventor does so at his own expense, for the chances of commercial success seem still too distant to invite others to engage in the actual building of a flying machine, unless they do it with the understanding that they lose their money. This is the course which has thus far been followed by the three or four experimenters who now seem in the lead, and it may be long before they achieve such success as fairly to warrant them in proceeding to the construction of a full-sized machine.

In any event, without concerning ourselves with the possible commercial uses of such apparatus, we may hope here to advance knowledge upon this interesting problem, and to be of service to those ingenious men who are seeking for its mechanical solution.

PIXOL is a water-soluble form of wood tar, prepared by warming together three parts of tar and one part of green soap, and gradually adding three parts of a 10 per cent. solution of potash. It is a brown, clear, thick fluid and not greasy in water solutions nor caustic, and found valuable for the sterilization of cultures of bacteria, from which it is argued that it will prove a good disinfecting agent.

THE END OF OUR WORLD.

By CAMILLE FLAMMARION.

THE following article by Camille Flammarion is from the New York *Herald*, from advance sheets of the *Cosmopolitan Magazine* for August, and presents an interesting forecast of the end of the world, based on scientific principles.

The last habitable regions of the globe were two wide valleys near the equator, the basins of dried-up seas, valleys of slight depth, for the general level was almost absolutely uniform. No mountain peaks, ravines, or wild gorges, not a single wooded valley or precipice was to be seen; the world was one vast plain, from which rivers and seas had gradually disappeared. But as the action of meteorological agents, rainfall and streams, had diminished in intensity with the loss of water, the last hollows of the sea bottom had not been entirely filled up, and shallow valleys remained, vestiges of the former structure of the globe. In these a little ice and moisture were left, but the circulation of water in the atmosphere had ceased, and the rivers flowed in subterranean channels as in invisible veins.

As the atmosphere contained no aqueous vapor, the sky was always cloudless and there was neither rain nor snow. The sun, less dazzling and less hot than formerly, shone with the yellowish splendor of a topaz. The color of the sky was sea green rather than blue. The volume of the atmosphere had diminished considerably. Its oxygen and hydrogen had become in part fixed in metallic combinations, as oxides and nitrides, and its carbonic acid had slowly increased, as vegetation, deprived of water, became more and more rare and absorbed an ever-decreasing amount of this gas. But the mass of the earth, owing to the constant fall of meteorites, bolides and uranolites, had increased with time, so that the atmosphere, though considerably less in volume, had retained its density and exerted nearly the same pressure.

Strangely enough the snow and ice had diminished as the earth grew cold. The cause of this low temperature was the absence of water vapor from the atmosphere, which had decreased with the superficial area of the sea. As the water penetrated the interior of the earth and the general level became more uniform, first the depth and then the area of seas had been reduced, the invisible envelope of aqueous vapor had lost its protecting power, and the day came when the return of the heat received from the sun was no longer prevented. It was radiated into space as rapidly as it was received, as if it fell upon a mirror incapable of absorbing its rays.

Such was the condition of the earth. The last representatives of the human race had survived all these physical transformations solely by virtue of its genius of invention and power of adaptation. Its last efforts had been directed toward extracting nutritious substances from the air, from subterranean water, and from plants, and replacing the vanished vapor of the air by buildings and roofs of glass.

It was necessary at any cost to capture these solar rays and to prevent their radiation into space. It was easy to store up this heat in large quantities, for the sun shone unobscured by any cloud and the day was long—fifty-five hours.

For a long time the efforts of architects had been solely directed toward this imprisonment of the sun's rays and the prevention of their dispersion during the fifty-five hours of the night. They had succeeded in accomplishing this by an ingenious arrangement of glass roofs, superposed one upon the other, and by movable screens. All combustible material had long before been exhausted; and even the hydrogen extracted from water was difficult to obtain.

The mean temperature in the open air during the day time was not very low, not falling below 10°. Notwithstanding the changes which the ages had wrought in vegetable life, no species of plants could exist, even in this equatorial zone.

As for the other latitudes, they had been totally uninhabitable for thousands of years, in spite of every effort made to live in them. In the latitudes of Paris, Nice, Rome, Naples, Algiers, and Tunis all protective atmospheric action had ceased, and the oblique rays of the sun had proved insufficient to warm the soil, which was frozen to a great depth, like a veritable block of ice. The world's population had gradually diminished from ten milliards to nine, to eight, and then to seven, one-half the surface of the globe being then habitable. As the habitable zone became more and more restricted to the equator, the population had still further diminished, as had also the mean length of human life, and the day came when only a few hundred millions remained, scattered in groups along the equator, and maintaining life only by the artifices of a laborious and scientific industry.

Later still, toward the end, only two groups of a few hundred beings were left, occupying the last surviving centers of industry. From all the rest of the globe the human race had slowly but inexorably disappeared—dried up, exhausted, degenerated, from century to century, through the lack of an assimilable atmosphere and sufficient food. Its last remnants seemed to have lapsed back into barbarism, vegetating like the Esquimaux of the north. These two ancient centers of civilization, themselves yielding to decay, had survived only at the cost of a constant struggle between industrial genius and implacable nature.

Even here, between the tropics and the equator, the two remaining groups of human beings which still contrived to exist in the face of a thousand hardships which yearly became more insupportable, did so only by subsisting, so to speak, on what their predecessors had left behind. These two ocean valleys, one of which was near the bottom of what is now the Pacific Ocean, the other to the south of the present island of Ceylon, had formerly been the sites of two immense cities of glass—iron and glass having been for a long time the materials chiefly employed in building construction. They resembled vast winter gardens, without upper stories, with transparent ceilings of immense height. Here were to be found the last plants, except those cultivated in the subterranean galleries leading to rivers flowing under ground.

Elsewhere the surface of the earth was a ruin, and even here only the last vestiges of a vanished greatness were to be seen.

The earth was dead. The other planets also had died one after the other. The sun was extinguished.

But the stars still shone; there were still suns and worlds.

In the measureless duration of eternity, time, an essentially relative conception, is determined by each world, and even in each world this conception is dependent upon the consciousness of the individual. Each world measures its own duration. The year of the earth is not that of Neptune. The latter is 164 times the former, and yet is not longer relatively to the absolute. There is no common measure between time and eternity. In empty space there is no time, no years, no centuries; only the possibility of the measurement of time which becomes real the moment a revolving world appears. Without some periodic motion no conception whatever of time is possible.

The earth no longer existed, nor her celestial companion, the little isle of Mars, nor the beautiful sphere of Venus, nor the colossal world of Jupiter, nor the strange universe of Saturn, which had lost its rings, nor the slow-moving Uranus and Neptune—not even the glorious sun, in whose fecundating heat these mansions of the heavens had basked for so many centuries. The sun was a dark ball, the planets also, and still this invisible system sped on in the glacial cold of starry space. So far as life is concerned, all these worlds were dead—did not exist. They survived their past history like the ruins of the dead cities of Assyria which the archæologist uncovers in the desert, moving on their way in darkness through the invisible and the unknown.

No genius, no magician, could recall the vanished past, when the earth floated bathed in light, with its broad green fields waking to the morning sun, its rivers winding like long serpents through the verdant meadows, its woods alive with the songs of birds, its forests filled with deep and mysterious shadows, its seas heaving with the tides or roaring in the tempest, its mountain slopes furrowed with rushing streams and cascades, its gardens enameled with flowers, its nests of birds and cradles of children, and its toiling population, whose activity had transformed it, and who lived so joyously a life perpetuated by the delights of an endless love. All this happiness seemed eternal. What has become of those mornings and evenings, of those flowers and those lovers, of that light and perfume, of those harmonies and joys, of those beauties and dreams? All is dead, has disappeared in the darkness of night.

The world dead, all the planets dead, the sun extinguished. The solar system annihilated, time itself suspended.

Time lapses into eternity, but eternity remains, and time is born again.

Before the existence of the earth, throughout an eternity, suns and worlds existed, peopled with beings like ourselves. Millions of years before the earth was they were. The past of the universe has been as brilliant as the present; the future will be as the past; the present is of no importance.

In examining the past history of the earth we might go back to a time when our planet shone in space, a veritable sun, appearing as Jupiter and Saturn do now, shrouded in a dense atmosphere charged with warm vapors, and we might follow all its transformations down to the period of man. We have seen that when its heat was entirely dissipated, its waters absorbed, the aqueous vapor of its atmosphere gone, and this atmosphere itself more or less absorbed, our planet must have presented the appearance of those great lunar deserts seen through the telescope (with certain differences due to the action of causes peculiar to the earth), with its final geographical configurations, its dried-up shores and water courses, a planetary corpse, a dead and frozen world. It still bears, however, within its bosom an unexpended energy—that of its motion of translation about the sun, an energy which transformed into heat by the sudden destruction of its motion would suffice to melt it and to reduce it in part to a state of vapor, thus inaugurating a new epoch, but for an instant only, for, if this motion of translation were destroyed, the earth would fall into the sun and its independent existence would come to an end. If suddenly arrested, it would move in a straight line toward the sun with an increasing velocity, and reach the sun in sixty-five days; were its motion gradually arrested, it would move in a spiral, to be swallowed up at last in the central luminary.

The entire history of terrestrial life is before our eyes. It has its commencement and its end, and its duration, however many the centuries which compose it, is preceded and followed by eternity—is, indeed, but a single instant lost in eternity.

For a long time after the earth ceased to be the abode of life, the colossal worlds of Jupiter and Saturn, passing more slowly from their solar to their planetary stage, reigned in their turn among the planets with the splendor of a vitality incomparably superior to that of our earth. But they also waxed old and descended into the night of the tomb.

Had the earth, like Jupiter, for example, retained long enough the elements of life, death would have come only with the extinction of the sun. But the length of the life of a world is proportional to its size and its elements of vitality.

The solar heat is due to two principal causes—the condensation of the original nebula and the fall of meteorites. According to the best established calculations of thermodynamics, the former has produced a quantity of heat eighteen million times greater than that which the sun radiates yearly, supposing the original nebula was cold, which there is no reason to believe was the case. It is, therefore, certain that the solar temperature produced by this condensation far exceeded the above. If condensation continues, the radiation of heat may go on for centuries without loss.

The heat emitted every second is equal to that which would result from the combustion of eleven quadrillions six hundred thousand milliards of tons of coal burning at once! The earth intercepts only one five hundredth millionth part of the radiant heat, and this one five hundredth millionth suffices to maintain all terrestrial life. Of sixty-seven millions of light and heat rays which the sun radiates into space, only one is received and utilized by the planets.

Well! to maintain this source of heat it is only necessary that the rate of condensation should be such that the sun's diameter should decrease seventy-seven meters a year, or one kilometer in thirteen years. This contraction is so gradual that it would be wholly imperceptible. Nine thousand five hundred years would be required to reduce the diameter by one single second of arc.

(*To be continued.*)

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